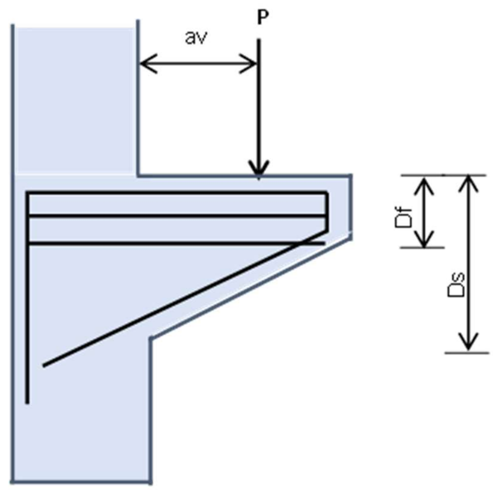
Corbel design

The basic principle of the design is "**strut-and-tie**" method similar to truss.



The requirement of the corbel is the ratio of $r = a_v/d$. The ratio shall be less than 2. Where d = effective overall depth (Ds minus effective cover). However, ratio $r = \frac{a_v}{d} \leq 0.6$ in any case.

Again, effective overall depth shall be such that $\tau_m = \tau_c * \left(\frac{2d}{a_v}\right)$ where $\tau_c =$ design shear strength of the concrete, depends on the grade of concrete and shall not be greater than $0.8\sqrt{f_{ck}}$ or 5 N/mm^2

The dimensioning of the bracket shall be such that bearing pressure on concrete shall be

i. Bearing with no padding material $0.4f_{ck}$.
ii. Bearing in cement mortar $0.6f_{ck}$ (Bedded bearing)
iii. Bearing on steel plate cast into member $0.8f_{ck}$.
iv. Flexible pads $0.5f_{ck}$.

Check for the bearing area

$$\sigma_b = 0.8f_{ck}$$

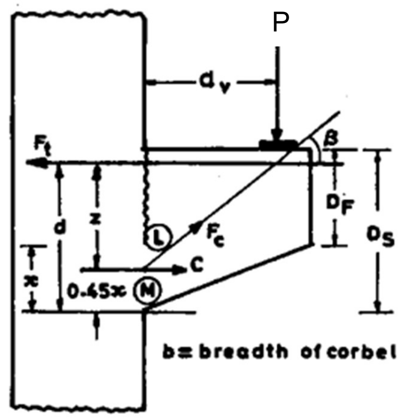
Bearing area

$$A_b = \frac{P * 1000}{\sigma_b}$$

And length of bearing plate

$$l_b = \frac{A_b}{b}$$

Where $b =$ width of the corbel



Using strut-and-tie method

$$P = F_c \sin(\beta)$$

And $Sin(\beta) = \frac{z}{\sqrt{a_v^2+z^2}}$ and therefore

$$F_c = P * \frac{\sqrt{a_v^2 + z^2}}{z}$$

Similarly,

$$F_t = F_c * \cos(\beta)$$

$$F_t = P * \frac{a_v}{z}$$

Where $z = (d - .45x)$ and hence $x = \frac{d-z}{0.45}$

Calculation of k

$$k = \frac{P * 1000}{0.87 f_{ck} bd}$$

And therefore $z = \frac{\left(\frac{r}{r+k} + \sqrt{\left(\frac{r}{r+k}\right)^2 - 4 * \left(\frac{k}{r+k}\right)\left(\frac{a}{d}\right)^2}\right)}{2} * d$

Reinforcement design

Calculation of main steel

1. Calculation of strain at the steel

$$\varepsilon_s = \varepsilon_c * \frac{d - x}{x}$$

And $\varepsilon_c = 0.0035$

$$f_s = \varepsilon_s E_s$$

If $f_s > 0.87 f_y$ then $f_s = 0.87 f_y$ otherwise $f_s = \varepsilon_s E_s$ where $E_s = 2x10^5$ N/mm^2 (Young's modulus of steel). For ε_s follow the stress-strain curve of reinforcement (Fig.23 of IS 456:2000 or Table A of SP16)

Area of main steel

$$A_{st} = \frac{F_t}{f_s}$$

Check for minimum reinforcement

$$A_{min} = 0.4\% \; of \; bd$$

Horizontal shear reinforcement shall be

$$A_{su} = \frac{A_{st}}{2}$$

Corbels in precast construction

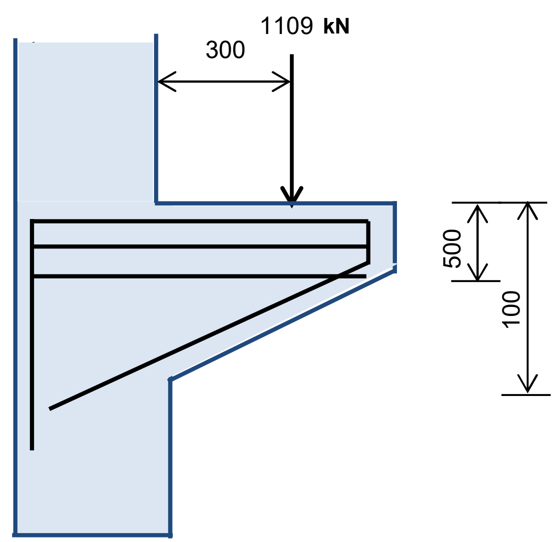
Design of corbel as per IS 456

Project: Sankhuwa Hydropower Project | Date: 2/1/2023

Prepared by: | Checked by: | Approved by:

INPUT	Symbol	Value	Unit
Design parameters			
Grade of Concrete		M25	
Characteristic Strength of Concrete	f_{ck}	25	N/mm^2
Grade of Steel for main bar	*fy*	500	N/mm^2
Grade of steel for shear reinforcement	f_s	250	N/mm^2
Types of bars		Deformed	
Clear Cover	*d*	40	mm
Modulus of Elasticity of Steel	E_s	200000	N/mm^2
FACTORED LOAD			
Vertical load	*Fv*	1109	kNm
Distance of load from support	a_v	300	mm
DIMENSIONING OF CORBEL			
Width of corbel		1400	mm
Length of bearing pad		40	mm
Depth of bracket at support		1000	mm
Depth of corbel at far end		500	mm
Check for depth			
At bracket		1000.0	mm
Far end		500.0	mm
Check for strut ratio av/d		OK	
DESIGN CALCULATION			
Tensile force	*Ft*	388.0	kN
Compressive force	*Fc*	1174.5	kN

OUTPUT				
Size of corbel				
Width			1400	mm
Depth	At bracket		1000	mm
	At end		500	mm
Reinforcement				
Main bar			Dia, mm	Nos
			25	11
Shear bar		Dia,mm	Legs	Spacing,mm
		12	4	160.0



REINFORCEMENT DESIGN	Main reinforcement	Shear reinforcement	
Area of bar	5376.00	2688.00	mm^2
Diameter	**25**	**12**	mm
Number of legs for shear bar		4	Nos
Number/Spacing	11	160.0	Nos/mm
Area of bar provided	5399.61		
Percentage of bar	0.41		%
Shear capacity of corbel		5043.28	kN
Check for shear capacity		OK	