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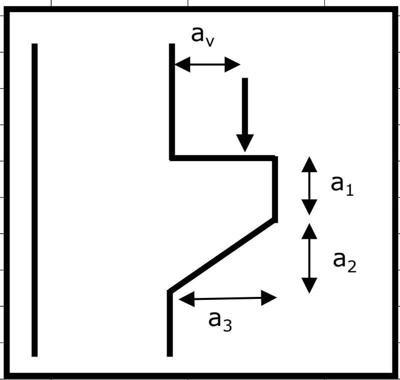
Material Properties

Characteristic strength of concrete, f_{cu} (≤ 60N/mm^2; HSC N/A)	35	N/mm^2	OK
Yield strength of longitudinal steel, f_y	460	N/mm^2	
Yield strength of shear link steel, f_{yv}	460	N/mm^2	
Elastic modulus of steel, E_s	205000	N/mm^2	
Ultimate strain of concrete, ε_{cc}	0.0035		

Dimensions



Width, b		1000	mm	
Dimension, a_1		450	mm	
Dimension, a_2		450	mm	
Dimension, a_3		300	mm	
Distance of centreline of applied load from face of column, a_v	300	425	mm	*cl.5.2.7.1*
(Note a_v should be taken as a_3 for stiff bearing and $a_3/2$ for flexible bearing)				*BS8110*

(Note cl.6.2.3(8) EC2 which states that a_v should be taken as greater than 0.5d is nevertheless considered even as that clause presumably applies to vertical shear reinforcement)

Effective depth to tensile steel, $d = a_1 + a_2 - \text{cover} - \phi_t/2$	849	mm	
Shear span to depth ratio, a_v/d (≤ 1.00 *cl.5.2.7.1 BS8110*)	0.50		OK

Reinforcement

Cover to all reinforcement, cover (usually 35 (C35) or 30 (C40) internal; 40 e:	35	mm	
Tension steel reinforcement diameter, ϕ_t (>= 10mm)	32	mm	OK
Tension steel reinforcement number, n_t	10		
Tension steel area provided, $A_{s,prov,t} = n_t.\pi.\phi_t^2/4$	8042	mm^2	
Horizontal shear link diameter, ϕ_{link}	25	mm	
Number of horizontal links in a cross section, i.e. number of legs, n_{leg}	4		
Number of cross sections of horizontal links within d, n_{sec}	4		

(Note horizontal links to be provided within upper 2/3 of effective depth as per cl.5.2.7.2.3 BS8110)

Area provided by all horizontal links within d, $A_{sv,prov} = \pi.\phi_{link}^2/4.n_{leg}.n_{sec}$	7854	mm^2

Loading

ULS applied load, N	1800	kN

Executive Summary

Item	UT	Remark
Bearing stress utilisation	49%	OK
Tension reinforcement utilisation	30%	OK
Ultimate shear stress utilisation	45%	OK
Design shear resistance utilisation	28%	OK
Min tension steel reinforcement pitch utilisation	80%	OK
% Min tension reinforcement utilisation	42%	OK
% Max tension reinforcement utilisation	73%	OK
% Min shear reinforcement utilisation	11%	OK
% Min combined tension and shear reinforcement utilisa	38%	OK
% Max combined tension and shear reinforcement utilis	94%	OK
Total utilisation	**94%**	**OK**

Bearing Stress Limit

Bearing area, $A = b.(a_3 - r)$	265000	mm^2	
Reduction of dimension a_3 due to chamfer and gap, r	35	mm	
Bearing stress, $\sigma = N/A$	7	N/mm^2	
Bearing stress limit, $\sigma_{lim} = 0.4f_{cu}$	14	N/mm^2	
Bearing stress utilisation, σ/σ_{lim}	**49%**		**OK**

Tension Reinforcement Design

Parameter, $k = N / (0.9f_{cu}.b.a_v)$	0.13		
Lever arm, $z = d.(0.5+\sqrt{(0.25-(1+k).k.a_v^2/d^2)}) / (1+k)$	719	mm	
Depth to neutral axis, $x = (d-z) / 0.45$	290	mm	
Ratio x/d	0.342		
Tension steel yielded or not ?	Yielded		
(Note if x/d > 0.615, tension steel not yielded; and vice versa)			
Steel stress, f_{st}	437	N/mm^2	
(Note if not yielded, $f_{st} = E_s . \varepsilon_{cc}(d-x)/x$; else $f_{st} = 0.95f_y$)			
Tension force, $F_t = N.a_v/z$ (>= 0.5N)	1063	kN	
Area of tension steel required, $A_s = F_t / f_{st}$	2433	mm^2	
Area of tensile steel reinforcement provided, $A_{s,prov,t}$	8042	mm^2	
Tension reinforcement utilisation = $A_s / A_{s,prov,t}$	**30%**		**OK**
% Min tension reinforcement = 0.4%.bd	3396	mm^2	
% Min tension reinforcement utilisation	**42%**		**OK**
% Max tension reinforcement = 1.3%.bd	11037	mm^2	
% Max tension reinforcement utilisation	**73%**		**OK**
Tension reinforcement pitch = $(b - 2.cover - 2\phi_{link} - \phi_t)/(n_t-1)$	94	mm	
Min tension steel reinforcement pitch utilisation (>75mm, >100mm if T40)	**80%**		**OK**
(Note no allowance has been made for laps in the min pitch as not deemed to be required)			

Shear Reinforcement Design			*3.4.5.8 BS8110*
Ultimate shear stress, v_{ult}=N/bd (< $0.8f_{cu}^{0.5}$ & 5N/mm^2)	**2.12**	N/mm^2	
Ultimate shear stress utilisation	**45%**		**OK**
Design shear stress, v_d=N/bd	**2.12**	N/mm^2	
(Shear capacity enhancement by calculating v_d at support and comparing against enhanced v_c within 2d of the support as clause 3.4.5.8 BS8110 employed, that of clause 3.4.5.10 BS8110 not applicable;)			
Area of tensile steel reinforcement provided, $A_{s,prov,t}$	8042	mm^2	
ρ_w = 100$A_{s,prov,t}$/bd	0.95	%	
$v_c = (0.79/1.25)(\rho_w f_{cu}/25)^{1/3}(400/d)^{1/4}$; ρ_w<3; f_{cu}<40; $(400/d)^{1/4}$>0.67	**0.58**	N/mm^2	
Enhanced shear capacity, $2dv_c/a_v$	**2.30**	N/mm^2	
Enhanced shear capacity, $2dv_c/a_v$ (< $0.8f_{cu}^{0.5}$ & 5N/mm^2)	**2.30**	N/mm^2	
Note that the enhanced shear capacity is limited $0.8f_{cu}^{0.5}$ & 5N/mm^2;			
Check v_d < 0.5.($2dv_c/a_v$) for no horizontal links	**N/A**		
Concrete shear capacity $2dv_c/a_v$.(bd)	**1954**	kN	
Check v_d >= 0.5.($2dv_c/a_v$) for design horizontal links	**VALID**		
Provide horizontal shear links A_{sv} > $a_v b(v_d-2dv_c/a_v)/(0.95f_{yv})$ i.e. A	**1217**	mm^2	
(Ensure $v_d - 2dv_c/a_v$ >= 0.4; Ensure A_{sv} >= 0.5A_s;)			
Concrete and design horizontal links shear capacity ($A_{sv,prov}$)/a_v.(0.	**6530**	kN	
Area provided by all horizontal links within (2/3).d, $A_{sv,prov}$	5236	mm^2	
(Note cl.6.2.3(8) EC2 which states that only links within the central 0.75a_v effectively cross the inclined shear cracks is not considered as that clause presumably applies to vertical shear reinforcement)			
Design shear resistance utilisation	**28%**		**OK**
Pitch of horizontal links, s_{link} = d / (n_{sec}-1)	283	mm	
% Min shear reinforcement = 0.2%.b.s_{link}	566	mm^2	
% Min shear reinforcement utilisation	**11%**		**OK**
% Min combined tension and shear reinforcement = 0.6%.bd	5094	mm^2	
% Min combined tension and shear reinforcement utilisation	**38%**		**OK**
% Max combined tension and shear reinforcement = 2.0%.bd	16980	mm^2	
% Max combined tension and shear reinforcement utilisation	**94%**		**OK**

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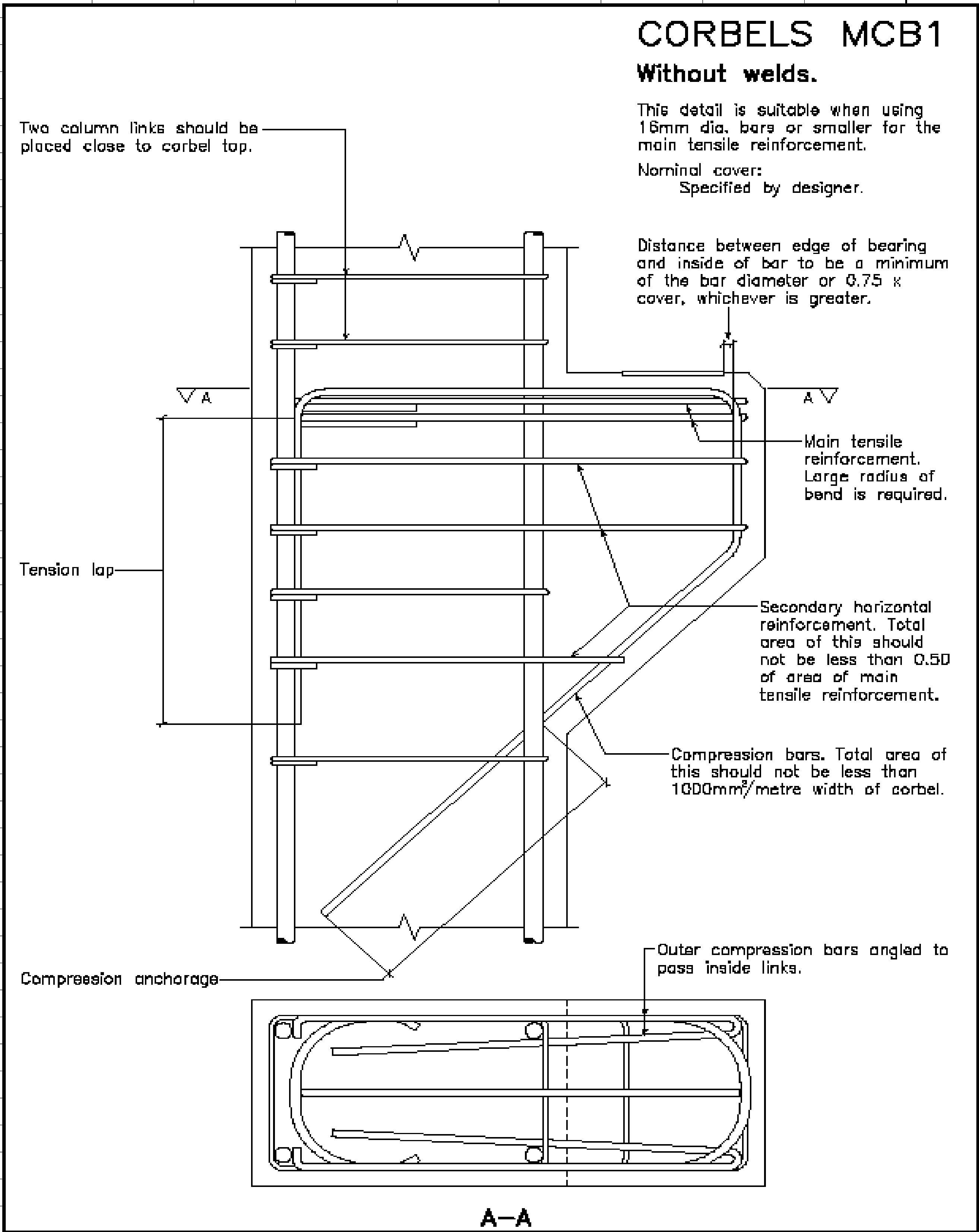
Standard Corbel Reinforcement Details



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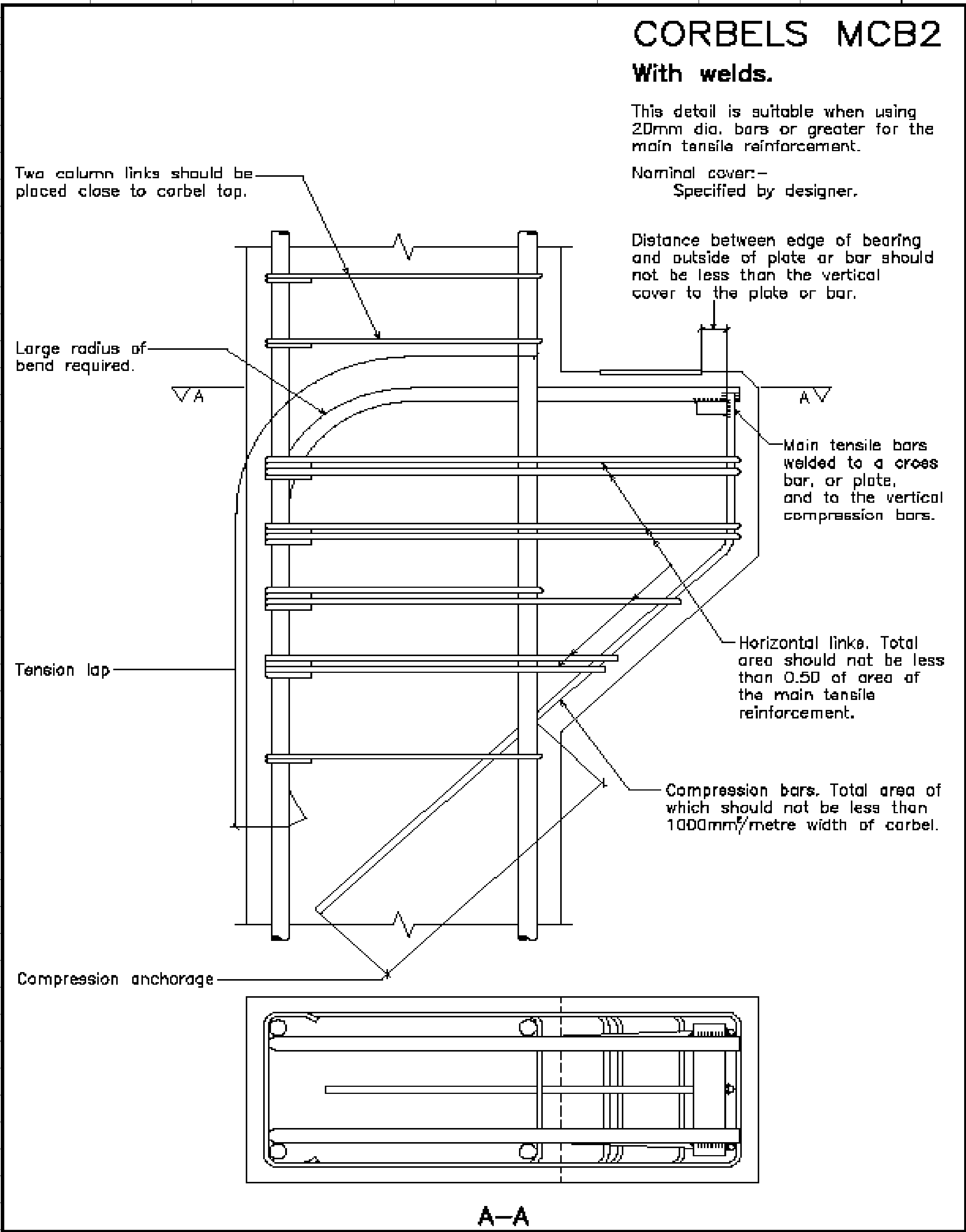


9.2.7 Arrangement of Reinforcement

The arrangement of reinforcement is very closely related to the design of corbels, half joints and nibs, and the designer must ensure that the detail design is clearly specified. He should refer to the OAP Design Guidance Notes, Concrete Construction: 4, May 1976. Other references are given in section 9.3.

In general small bar diameters, i.e. not larger than 16mm, should be used when detailing such elements. If larger diameter bars are used, it is likely that welding will be required. However, the designer should be aware that welding on site is not encouraged and if specified, often causes the contractor to suggest alternatives.

9.2.7.1 Corbels (BS 8110, Cl 5.2.7; EC2, Cl 5.4.4)

The use of small bar diameters, horizontal 'U' bars or links with easy bends is preferred, as shown in Model Detail MCB1. However, where the loading is high and the geometry restrictive, large bar diameters may be necessary, in which case welding them to a cross bar or plate may be the only solution. The size of this may be governed by the strength of weld. This is shown in Model Detail MCB2.

It is essential that the main tensile reinforcement is extended to as close to the outer face of the corbel as possible, and that it extends beyond the load bearing area by a minimum of the distance shown on the Model Details.

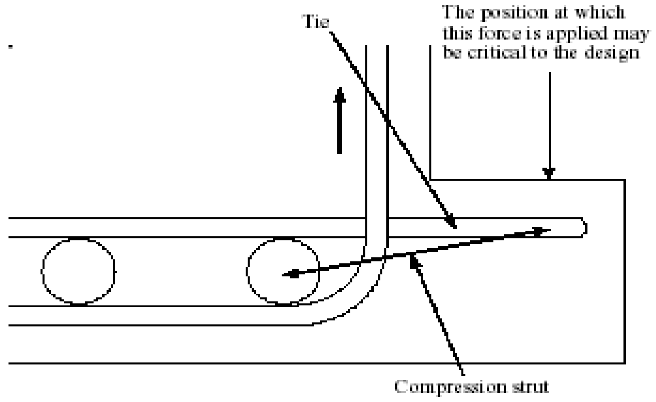
Where large horizontal forces are required to be transmitted into the corbel, a welded joint may be the only suitable solution. (See Park, R., and Paulay, T. Reinforced concrete structures.)

9.2.7.2 Half Joints in Beams

The use of inclined bars in half joints provides better control of cracking than other arrangements of reinforcement (See Clark L.A. and Thorogood P.: Serviceability behaviour of reinforced concrete half joints). However such bars are often difficult to fix correctly and can cause congestion of reinforcement. Great care is needed to ensure the use of practical details with inclined links or bent bars, especially when large bar diameters are required and a welded solution is adopted.

9.2.7.3 Continuous Nibs (BS 8110, Cl 5.2.8)

The arrangement of reinforcement for continuous nibs may control the depth of nib. Vertical 'U' bars or links should be used wherever possible, as shown in Model Detail MN1. However, where a shallow nib is required, e.g. for supporting brickwork, horizontal 'U' bars should be used, as shown in Model Detail MN2. The vertical leg of the links in the supporting beam must be designed to carry the loads from the nibs. The designer should note that it is necessary to reduce the value of d as the concrete in the nib below the vertical link does not contribute to the resistance. See Structures Note 1992NST_9, concerning Strut and Tie models.



In situations where horizontal movement may occur between the nib and the supported

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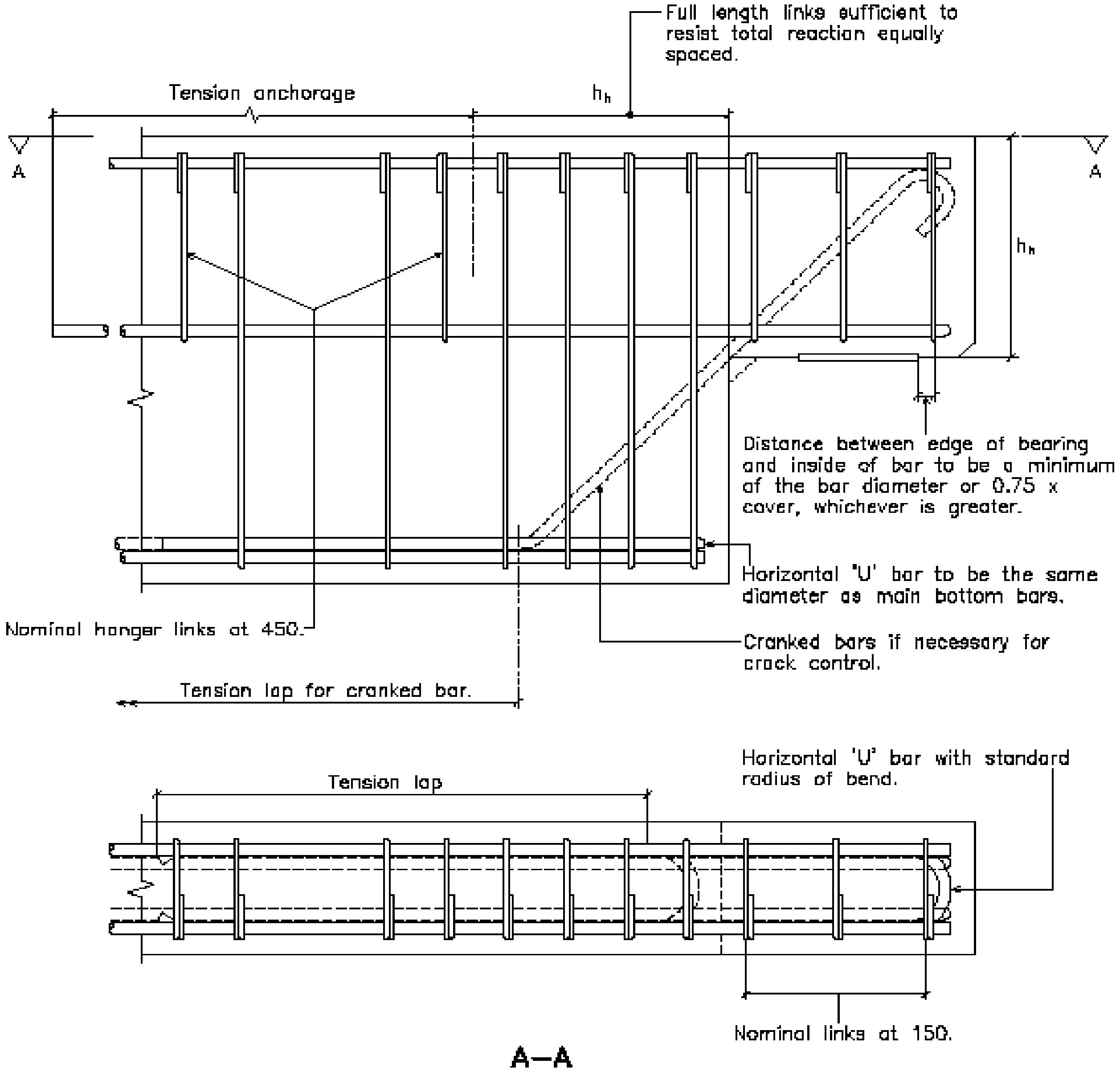
HALF JOINTS MHJ

Note:—
Special design information must be given concerning the bearing pads.

Nominal cover:—
Specified by designer. (Normally 40 to main steel).

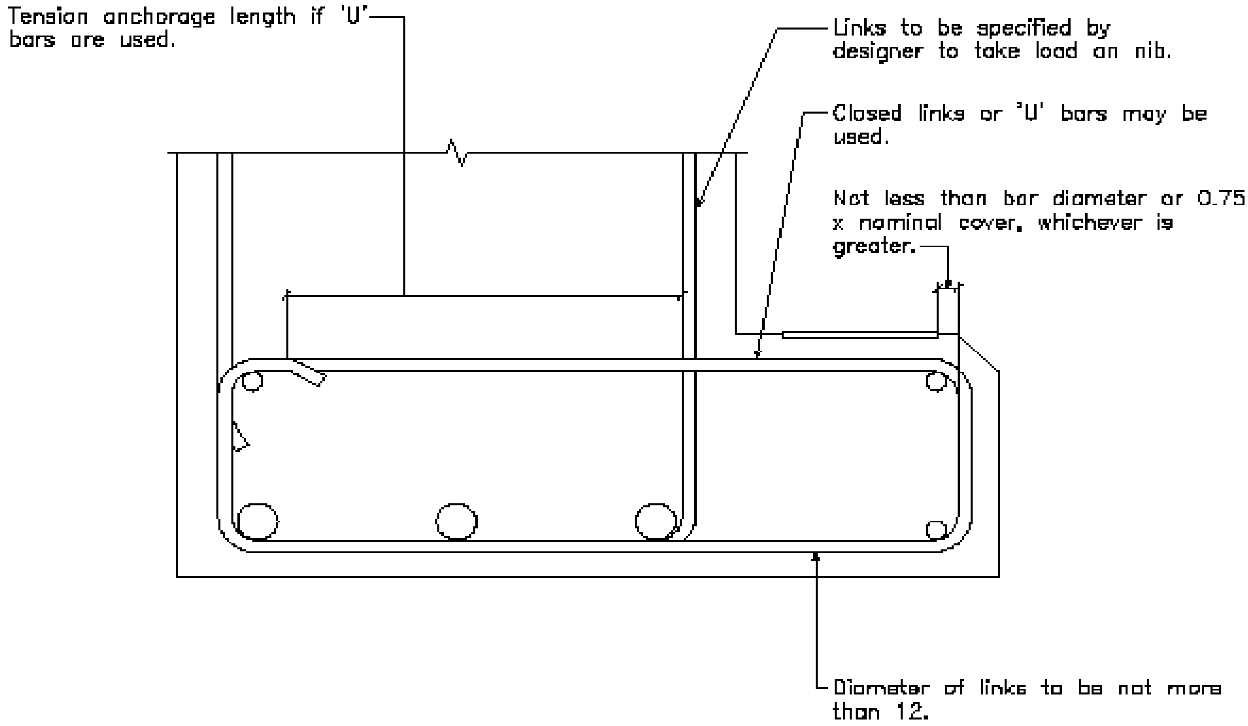


NIBS MN1

This detail is suitable for half joints in slabs.

Minimum nominal overlap of reinforcement in nib and reinforcement in supported member to be 60.

Nominal cover:— Specified by designer.



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