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Contact:
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Report 120927SCH

Steel balcony connections to concrete slabs using different connection methods

Client

Schock Ltd.

Oxford
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1. Objective

The aims of this investigation were:

a) To determine the heat loss, minimum surface temperature and hence temperature factor (f_{RSi}) resulting from use of Schock Isokorb Type KS14 units connecting a steel balcony support to a concrete floor slab.

b) To compare the calculated performance with that of structurally equivalent solutions such as with of no thermal isolation, and thermal break pads between a welded endplate and the concrete slab.

Calculation was by means of three-dimensional finite difference analysis using SOLIDO software from Physibel.

2. Description

Four situations were modelled, connecting a steel balcony support bracket to a 200mm intermediate floor slab in masonry wall construction:

- Case 1. Direct connection of balcony support bracket to concrete floor slab
- Case 2. 10mm 'thermal pad' using welded endplate on balcony support bracket
- Case 3. 20mm 'thermal pad' using welded endplate on balcony support bracket
- Case 4. KS14 unit connecting balcony support bracket to concrete slab

The Type KS14 H200 unit (200mm height, Figure 1) offers enhanced thermal resistance by using a combination of stainless steel reinforcement sections bearing on a cast stainless steel compression module encased in dense Styrofoam insulation. The basic installation as modelled is shown in Figure 2. The balcony is connected to an intermediate floor slab in a masonry construction.

The three-dimensional models were constructed using a close curve approximation as allowed by SOLIDO, for example Figure 3.

3. Calculations

SOLIDO v3.1 software from Physibel was used to construct three dimensional models of the applications described above in accordance with BS EN ISO 10211:1 (1996) [(1)]. Steady state solution was by means of the iterative finite difference method.

Table 1. Thermal conductivity

Material	k (W/mK)
Steel	50.00
Concrete slab	2.30
Brick	1.10
Wall insulation	0.04
Internal block	0.15
Plaster	0.70
Floor screed	1.40
Stainless steel	15.00
Neopor (Isokorb)	0.031
Timber	0.17

Boundary conditions

In the UK, surface resistances (R_s) are set in accordance with BS6946 [(2)] to determine U-values, thermal bridging heat loss, minimum surface temperature (and hence temperature factor). For walls:

Inside: t_{ai} = 20°C R_{si} = 0.13m^{2}K/W
Outside: t_{ae} = 0°C R_{so} = 0.04m^{2}K/W

In Germany, the surface resistances are set by DIN 4108-2 [(3)], which calls for different values to be used for determining minimum internal surface temperatures and hence temperature factor:

Inside: R_{si} = 0.25m^{2}K/W
Outside: R_{so} = 0.04m^{2}K/W

The UK result is presented in this report.

For the purpose of calculating the linear thermal bridging, the balcony support brackets were assumed to be set at 0.7m apart.

Wall and glazing U-values were 0.292W/m^{2}K and 0.997W/m^{2}K respectively.

Model representations are shown in Figures 3 to 7.

4. Results and conclusions

Table 2 presents the minimum surface temperatures and temperature factor for the cases modelled.

In the UK, the temperature factor (f_{RSi}) is used to indicate condensation risk as described in BRE IP1/06 (4), a document cited in Building Regulations Approved Documents Part L1 (5) and L2 (6).

Table 2. Temperature results

Description	Min. surface temp ℃	Temperature factor f_{RSi}
No balcony connection		0.949
Model 1 - Direct connection	13.62	0.681
Model 2 - Pad connection 10mm	14.26	0.713
Model 3 - Pad connection 20mm	14.11	0.706
Model 4 - KS14 H200	18.07	0.904

$f_{RSi} = (t_{smin} - t_{ao})/(t_{ai} - t_{ao})$

Where : t_{ai} = inside air temperature
T_{ao} = outside air temperature
T_{smin} = minimum internal surface temperature

For dwellings, f_{RSI} must be greater than or equal to 0.75, and for commercial buildings it must be greater than or equal to 0.5, calculated using an internal surface resistance of 0.13m^2K/W.

It can be seen that the KS14 unit, with f_{RSi} = 0.904, exceeds these values and will therefore meet the requirements of Building Regulations Approved Documents L1 and L2.

The results for the case with no unit (f_{RSi} =0.681) and with the 10mm and 20mm pad connections (f_{RSi} =0.713 and 0.706 respectively) are allowable for commercial buildings but would fail for dwellings and applications where there is a more humid environment (for example laundries and kitchens).

Table 3 presents areas and U-values for the flanking elements of the cases modelled.

Table 3. Flanking U-values and areas

Flanking element	Area m^2	U-value W/m^2K
1. Wall	A1 = 0.700	U1 = 0.292
2. Window frame	A2 = 0.049	U2 = 1.360
3. Window	A3 = 0.273	U3 = 0.997

Using the heat flow data from the results, with the data from Table 3, it is possible to calculate surplus heat flow due to detail, ψ (psi, linear thermal transmittance) and χ (chi, point thermal bridge)

$Q_{surplus}$ = $(Q/\Delta T) - (A1.U1) - (A2.U2) - (A3.U3)$

Ψ = $Q_{surplus}/0.7$

χ = $(Q_{connection} - Q_{no\ connection})/\Delta T$

Where: ΔT = temperature difference
Q = heat flow

Table 4. Heat flows and derived values

Description	Q (W)	2D/3D (W/K)	ψ (W/mK)	χ (W/K)
No connection	13.333	0.124	0.177	
Model 1 - Direct connection	24.620	0.688	0.983	0.564
Model 2 - Pad connection 10mm	23.096	0.612	0.874	0.488
Model 3 - Pad connection 20mm	24.527	0.683	0.976	0.560
Model 4 - KS14 H200	14.878	0.201	0.287	0.077

Use of a 10mm pad connection gives a small advantage, decreasing ψ by 11% . However, the 20mm pad, having a larger endplate connection, confers minimal advantage (0.7%). Use of the KS14 isolator reduces ψ by over 70%, as well as producing a temperature factor that allows the balcony connection to be used for residential applications.

Temperature distributions are shown in Figures 8 to 11.

References

1) BS EN ISO 10211-1:1996, Thermal Bridges in Building Construction – Heat flows and Surface Temperatures, General Calculation Methods BSI, 1996

2) BS6946:1997, Building Components and Building Elements – Thermal Resistance and Thermal Transmittance – Calculation method, BSI 1997

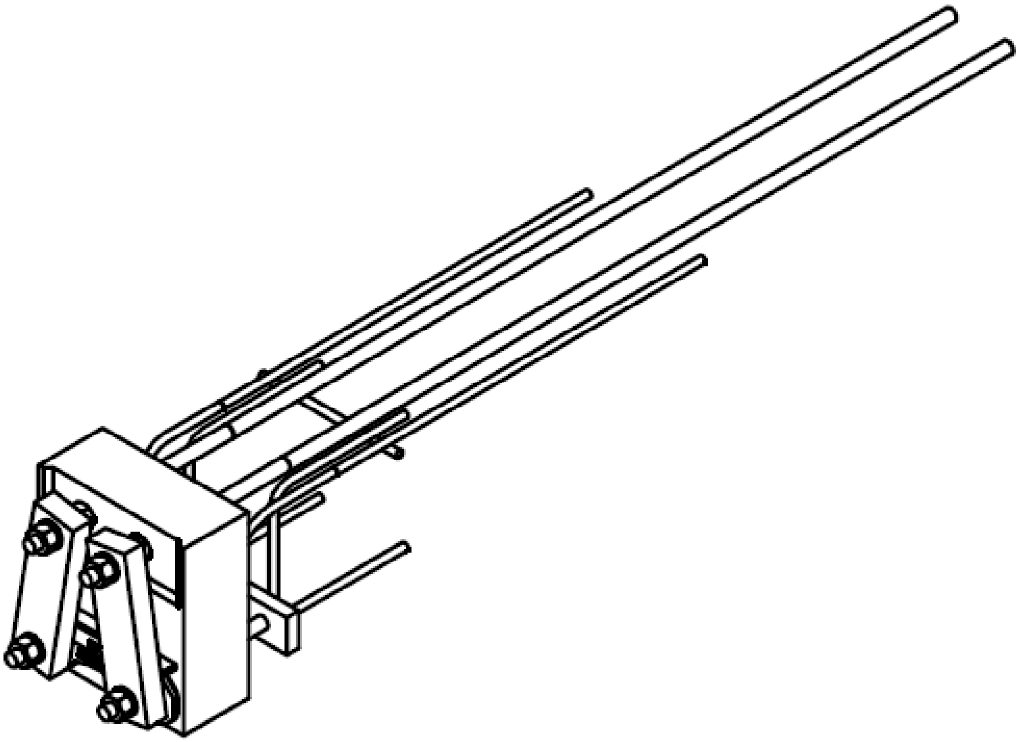
3) DIN4108-2:2003-07: Warmeschutz und Energie-Einsparung in Gebauden – Teil 2: Mindestanforderungen an den Warmeschutz. Beuth Verlag, Berlin

4) Ward T, Assessing the effects of thermal bridging at junctions and around openings, BRE IP1/06, Building Research Establishment 2006

5) Building Regulations Part L, Conservation of Fuel and Power, Approved Document L1, Conservation of Power in New Dwellings, April 2006

6) Building Regulations Part L, Conservation of Fuel and Power, Approved Document L2, Conservation of Power in New Buildings other than Dwellings, April 2006

Figures



Maße ohne Toleranzangabe = Allgemeintoleranz ISO 2768-c
Alle Maße in mm

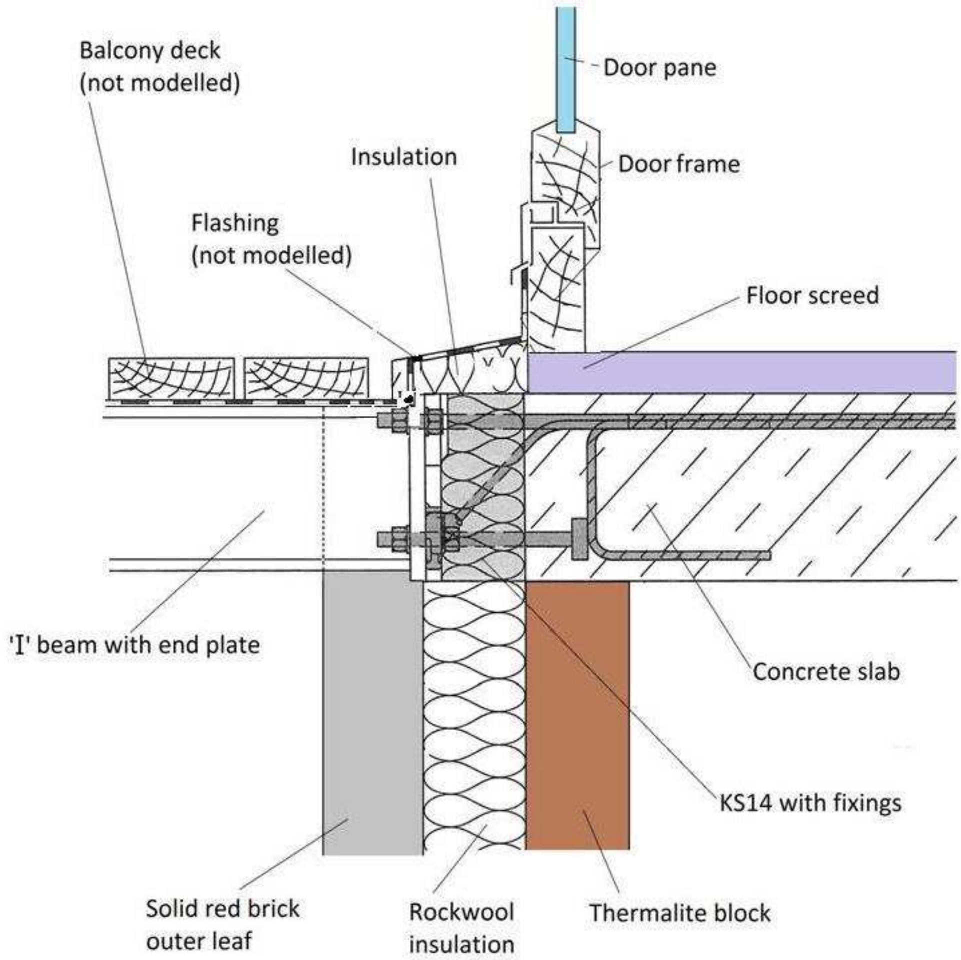
Nr.	Datum	bearbeitet	geprüft	Änderung
F1	12.02.09	U.Haas	A.Hofheinz	Winkel Q-Stäbe geändert (war 45°)
F2	29.05.09	U.Haas	A.Hofheinz	Durchmesser Montagestab von 6 auf 8mm geändert, Vorabzug entfernt

Schöck
Innovative Baulösungen

Schöck Isokorb Typ KS 14 V8, h = 200 mm

	Datum	Unterschrift	Maßstab	1:1 / 1:2 (A1)
gezeichnet	29.03.99	fl	Zeichnungs-Nr.	2521123-F
geprüft		su		

Figure 1. KS14 h200 unit.



Dimensions:

Length of projection:	l_k = 1.75 m
Balcony width:	b = 4,50 m
Inner slab slab thickness:	h = 200 mm
Height of Isokorb®:	H = 200 mm
Chosen axis separation:	a = 0,70 m

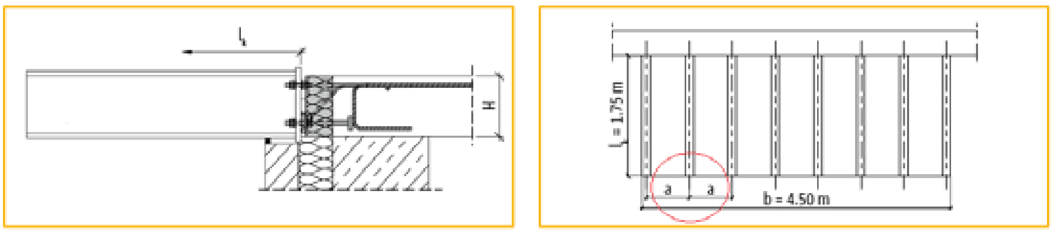


Figure 2. Schock KS14 unit: use with masonry wall and concrete slab

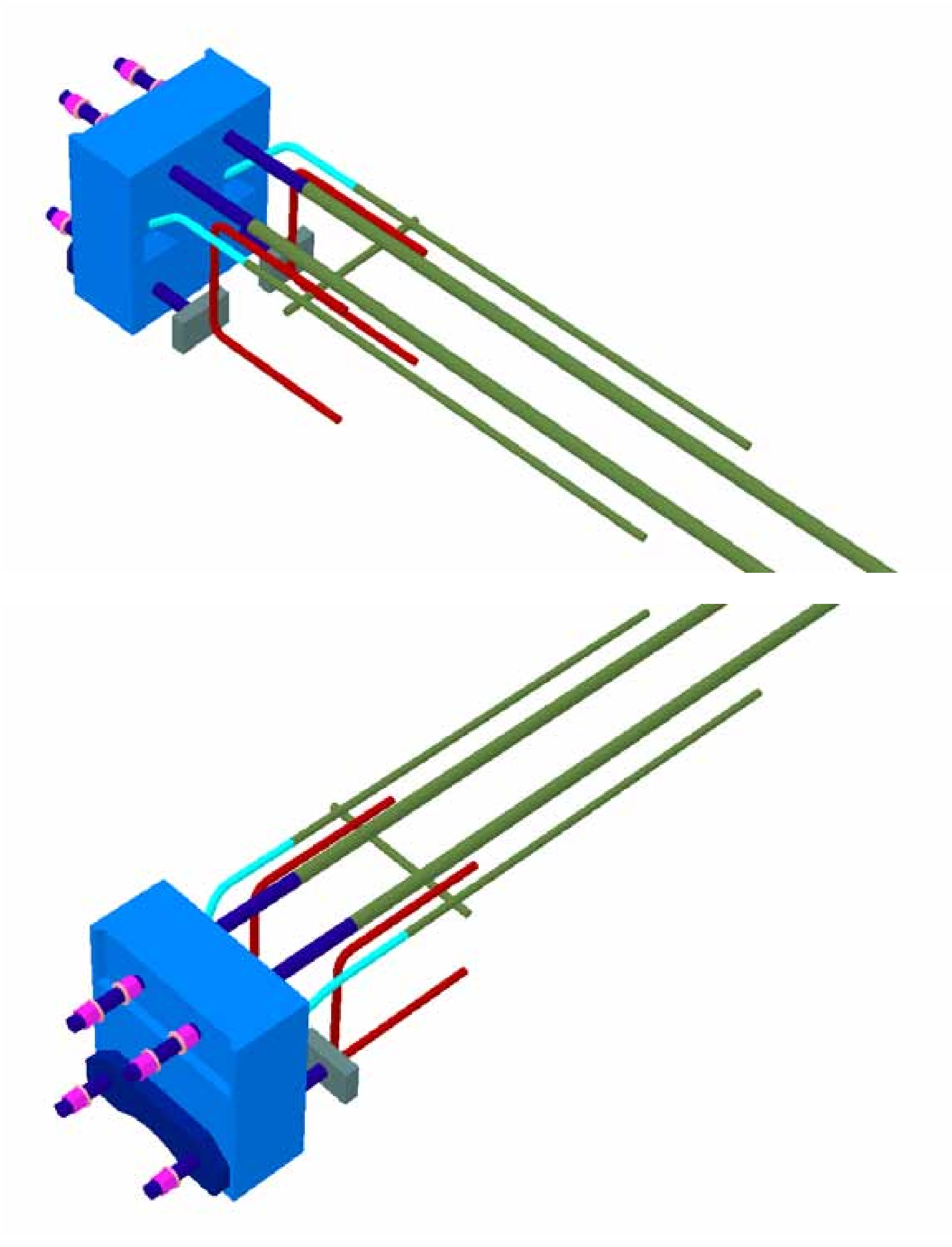


Figure 3. Schock KS14 unit: SOLIDO model (surrounding construction omitted for clarity)

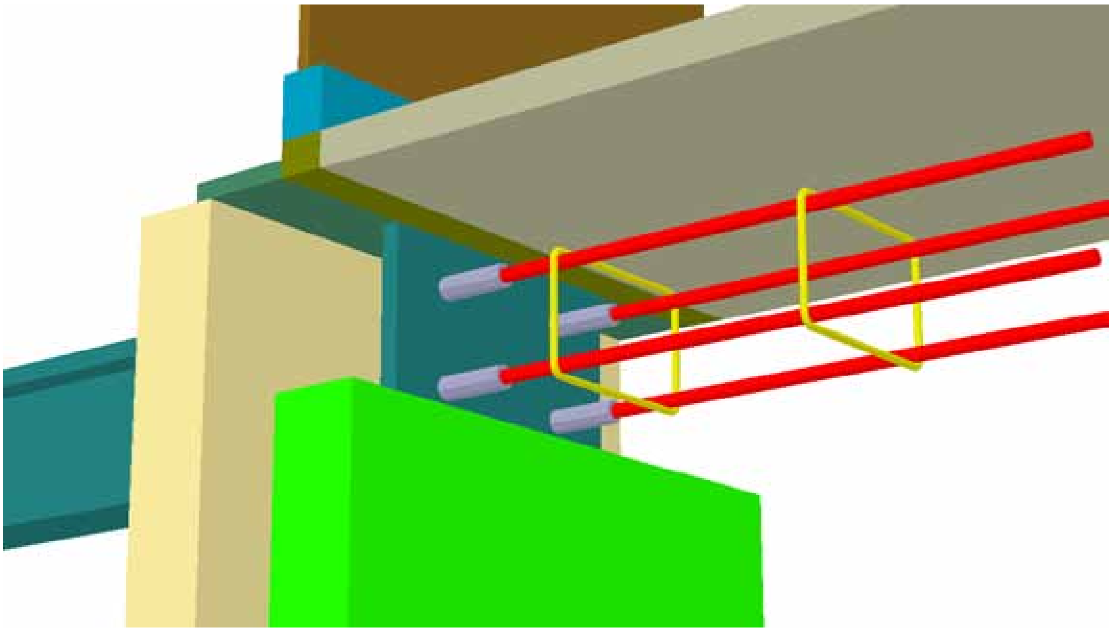


Figure 4. SOLIDO model of direct connection (Case 1), slab omitted for clarity

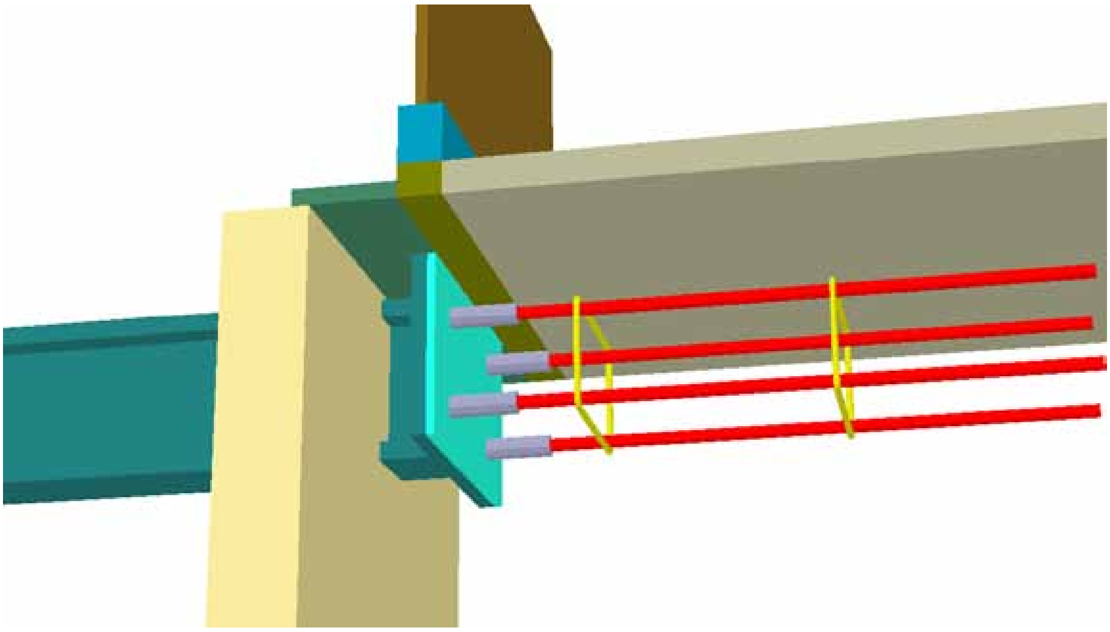


Figure 5. SOLIDO model of 10mm pad connection (Case 2), slab omitted for clarity

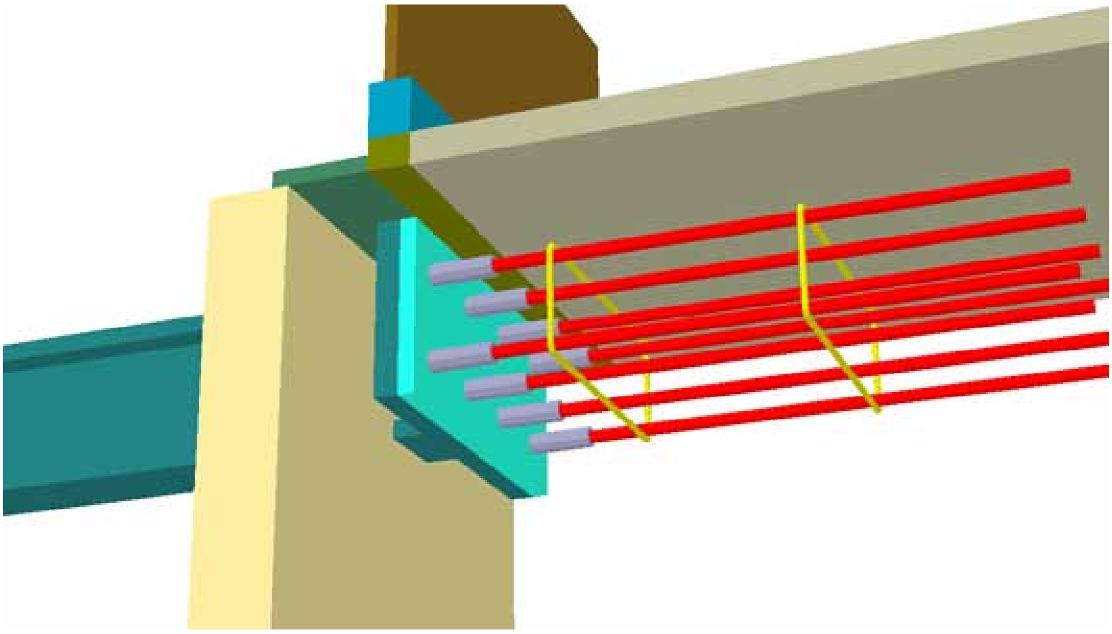


Figure 6. SOLIDO model of 20mm pad connection (Case 3), slab omitted for clarity

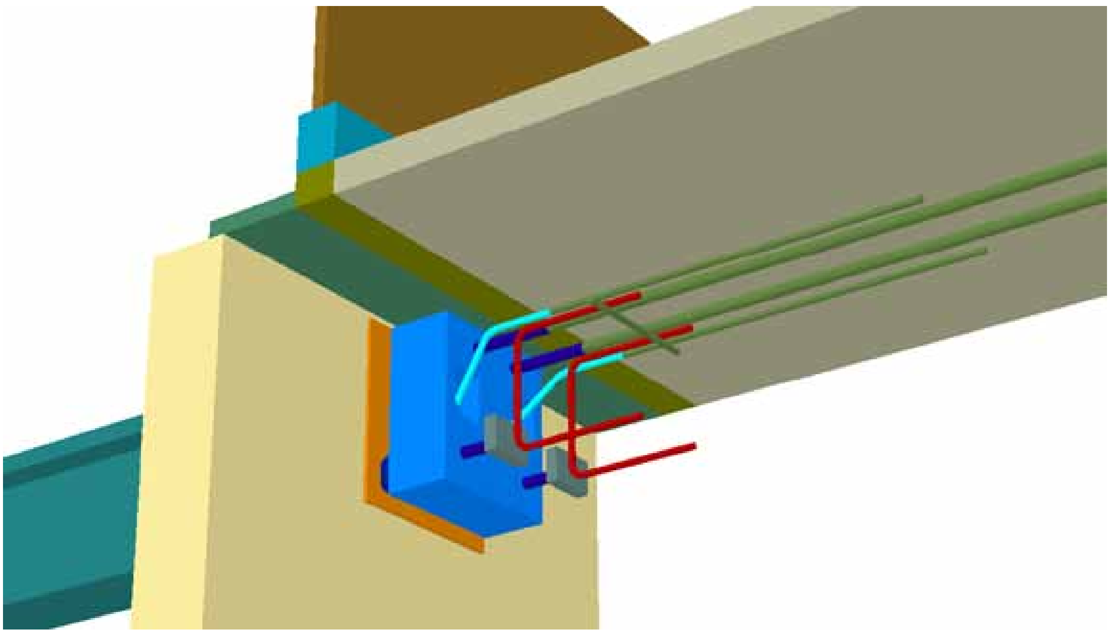


Figure 7. SOLIDO model of KS14 connection (case 4), slab omitted for clarity

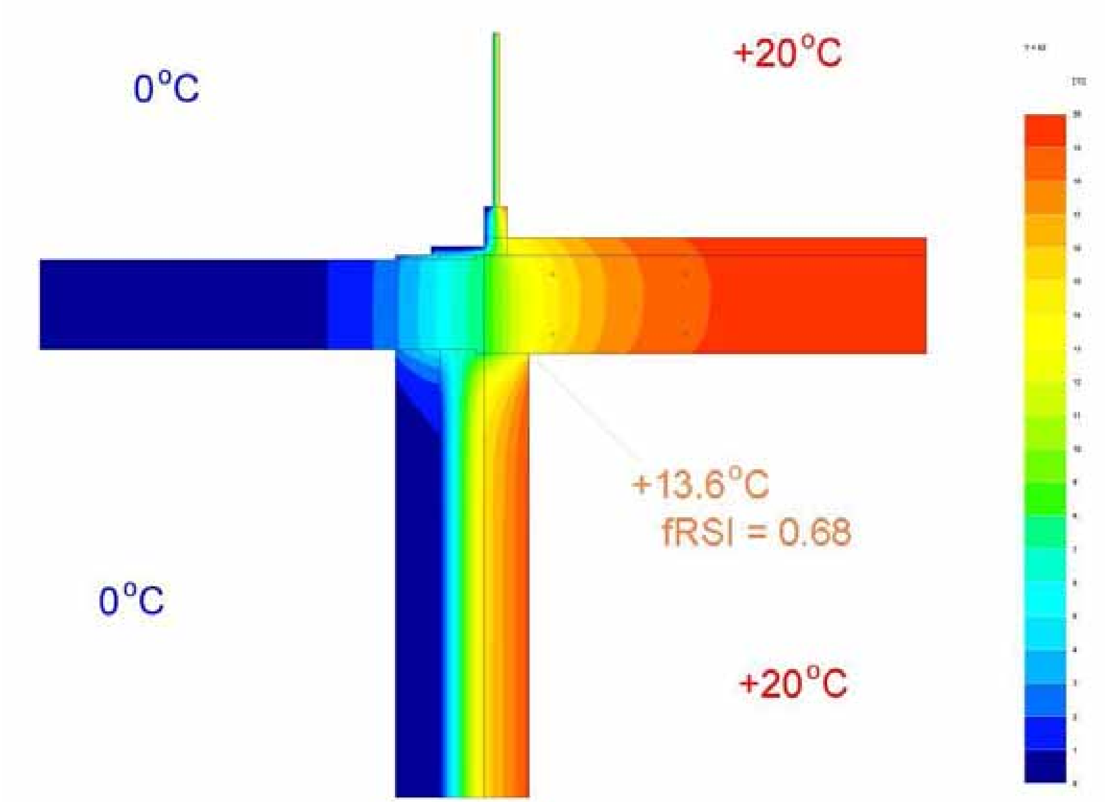


Figure 8. Direct connection (Case 1): temperature distribution (section)

This detail does NOT conform to UK Building Regulations Part L requirements for minimum temperature factor in dwellings (fRsi = 0.75)

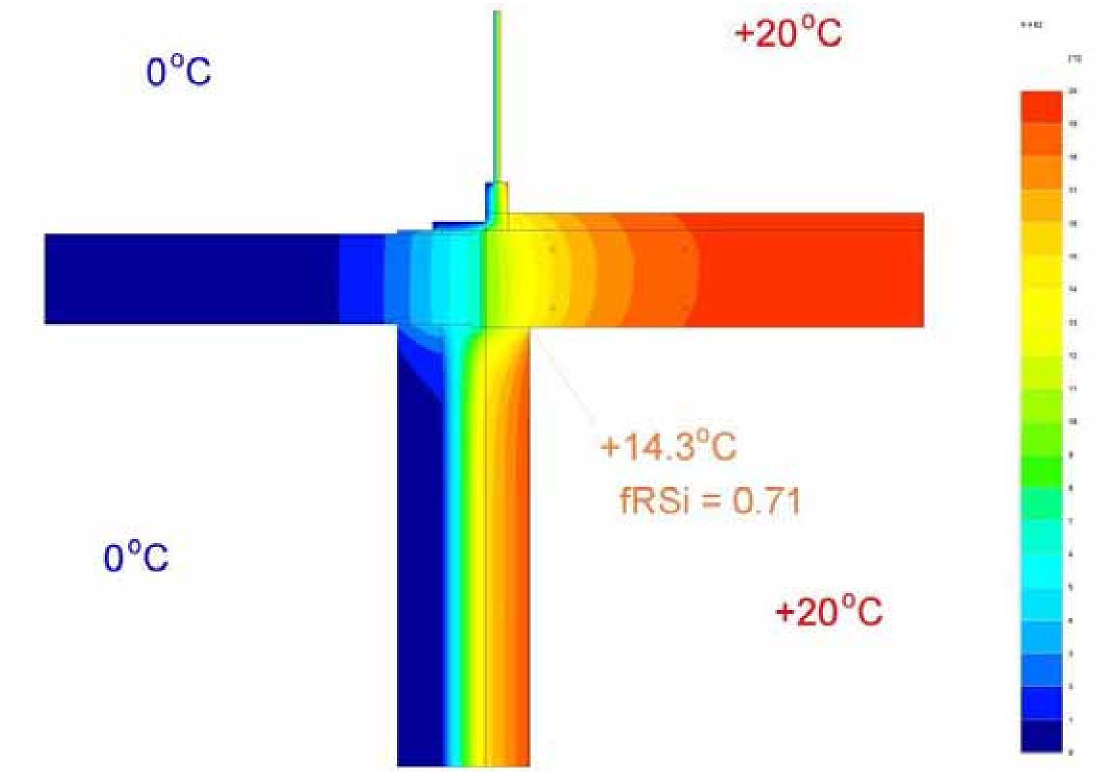


Figure 9. 10mm pad connection (Case 2): temperature distribution (section)

This detail does NOT conform to UK Building Regulations Part L requirements for minimum temperature factor in dwellings (fRsi = 0.75)

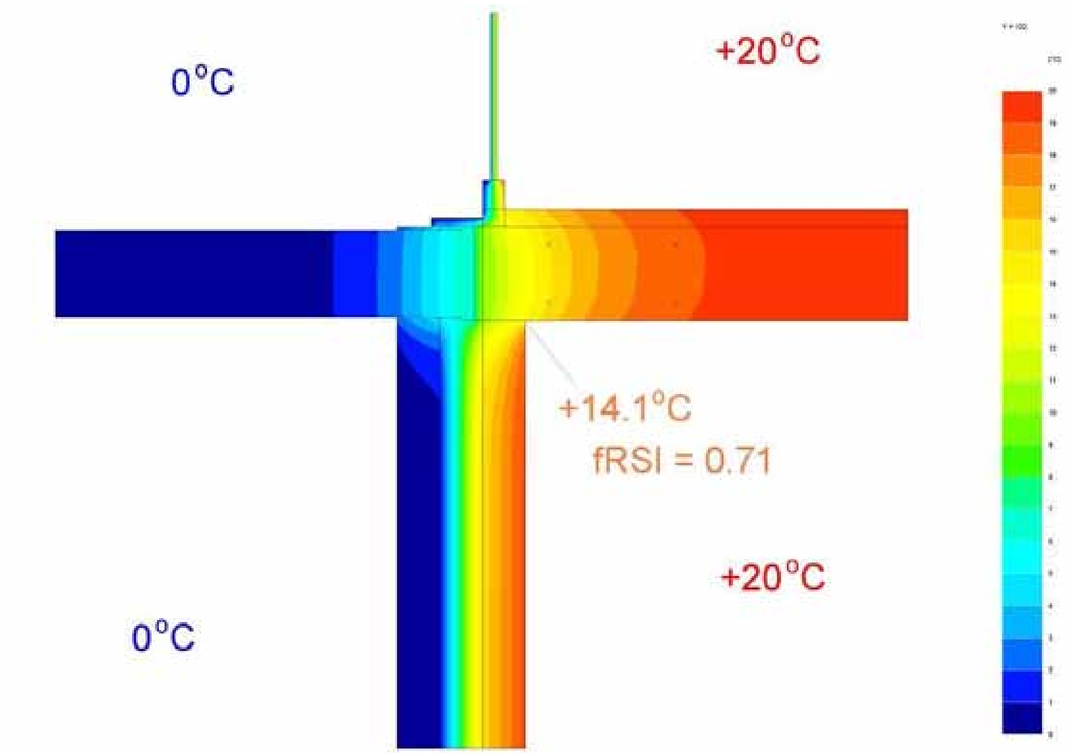


Figure 10. 20mm pad connection (Case 3): temperature distribution (section)

This detail does NOT conform to UK Building Regulations Part L requirements for minimum temperature factor in dwellings (fRsi = 0.75)

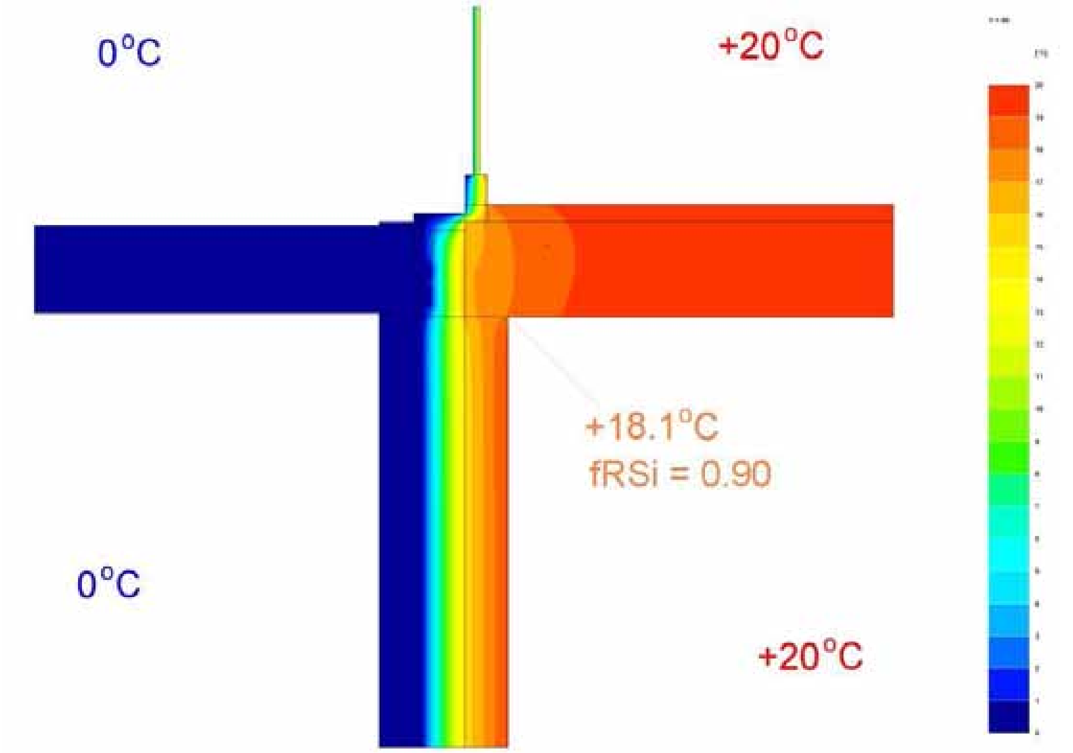
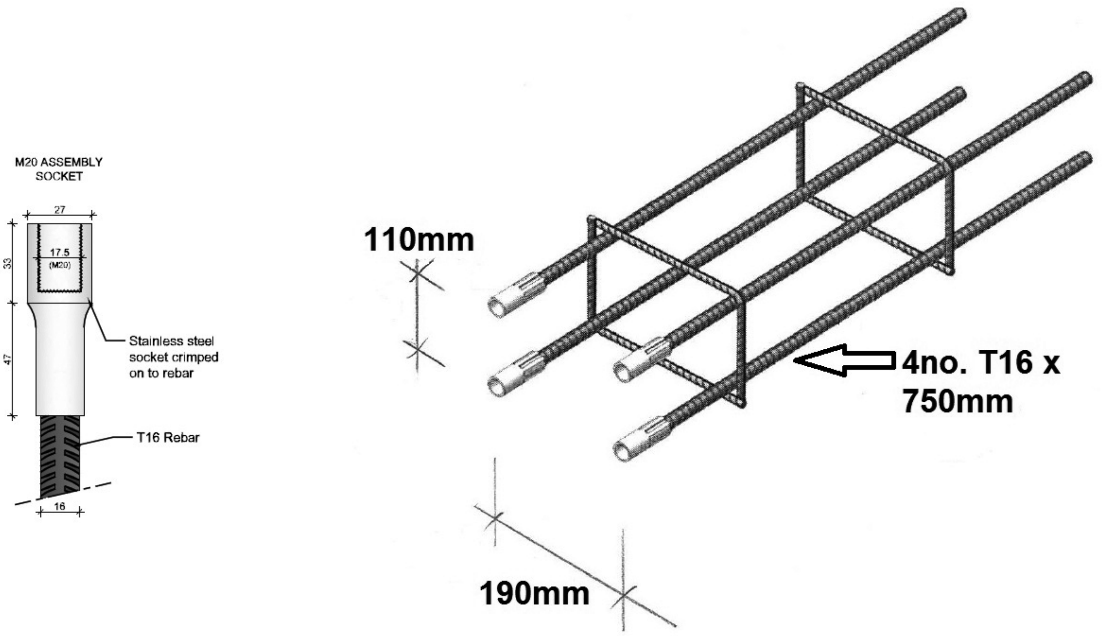


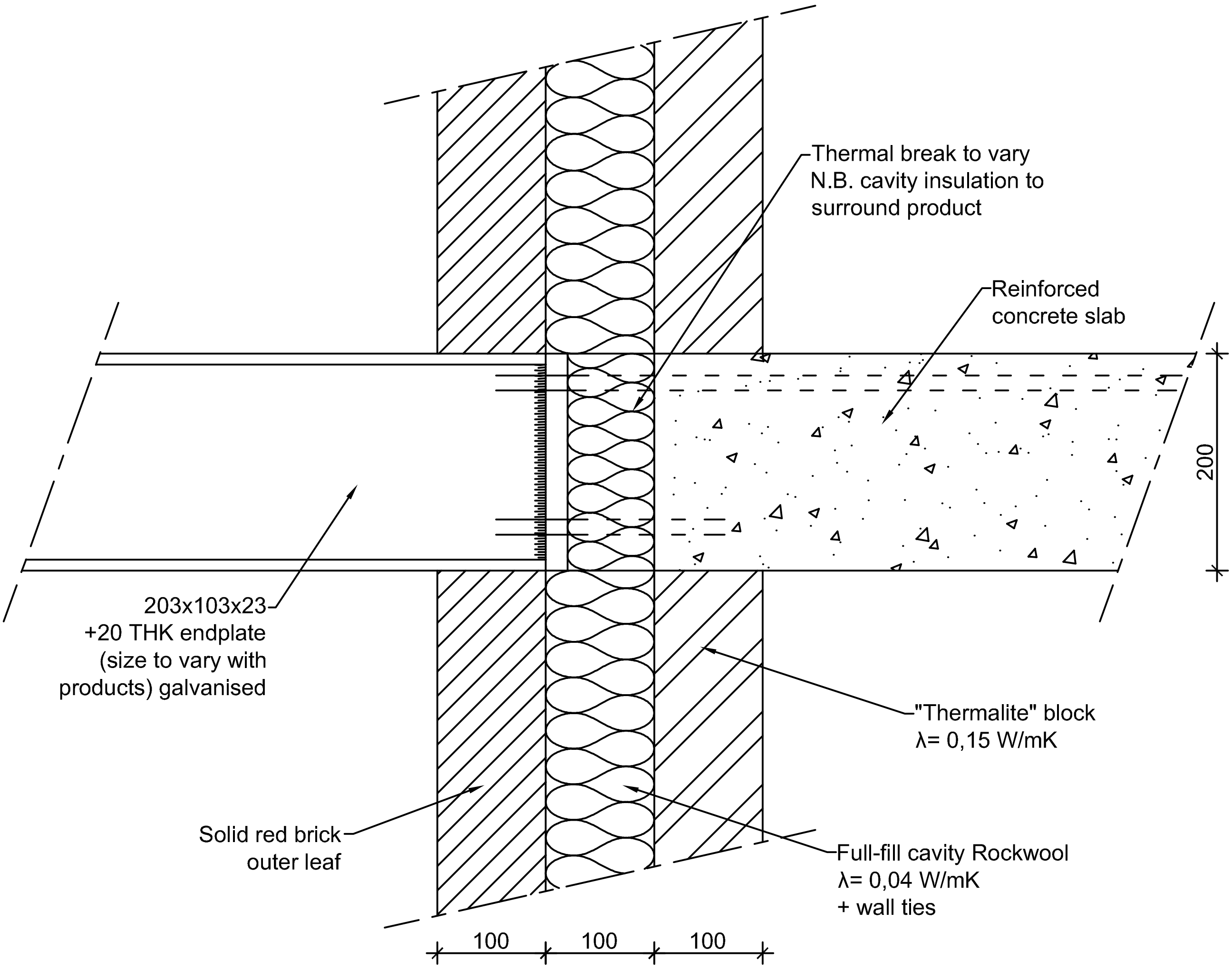
Figure 11. KS14 H200 connection (Case 4): temperature distribution (section)

This detail **conforms** with UK Building Regulations Part L requirements for minimum temperature factor in dwellings (fRsi = 0.75)

APPENDIX: Detail Drawings

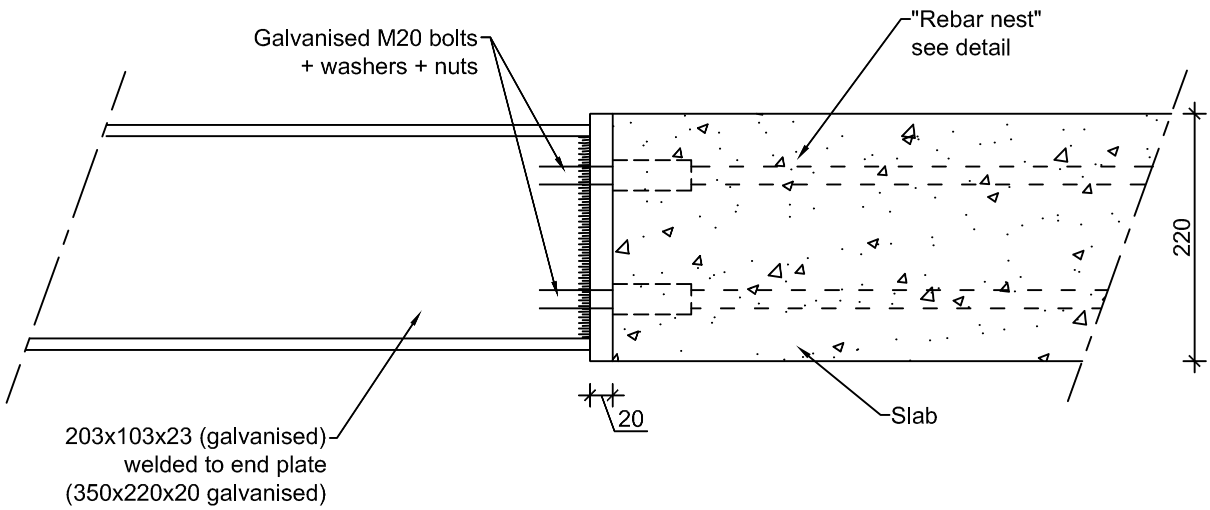
"REBAR NEST DETAIL"





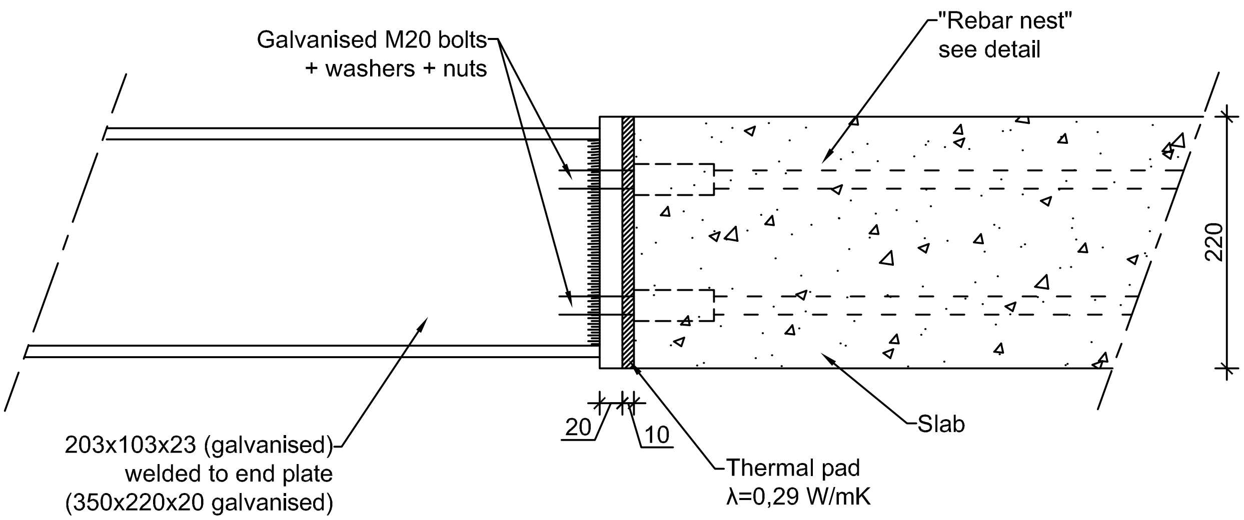
DETAIL 1
BASIC CONSTRUCTION

803513/02.2013/GB/130047

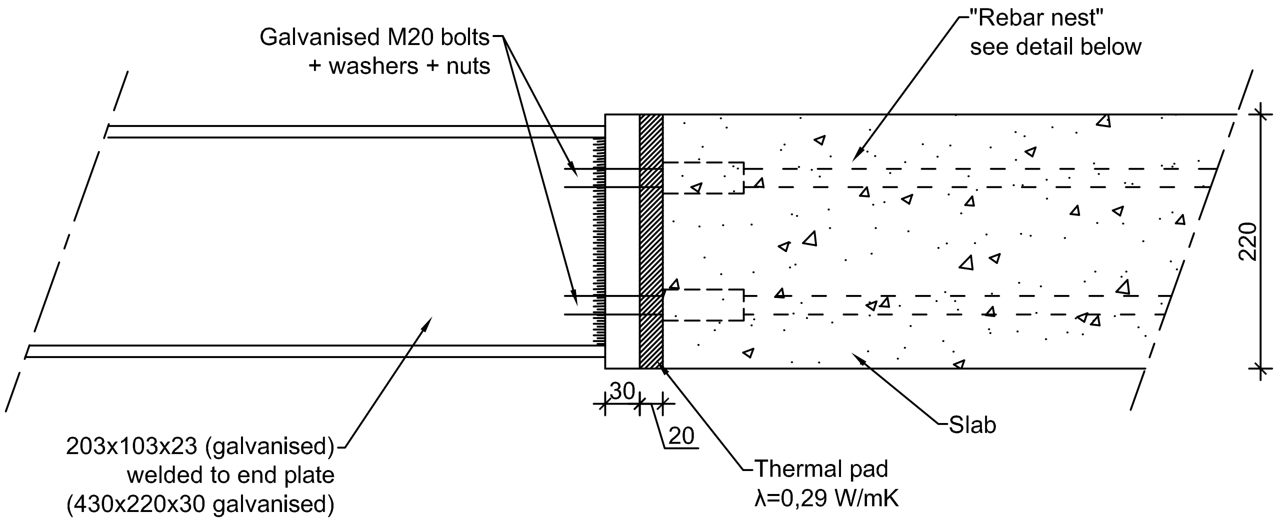


N.B. for complete construction please refer to DETAIL 1

DETAIL 2
DIRECT CONNECTION

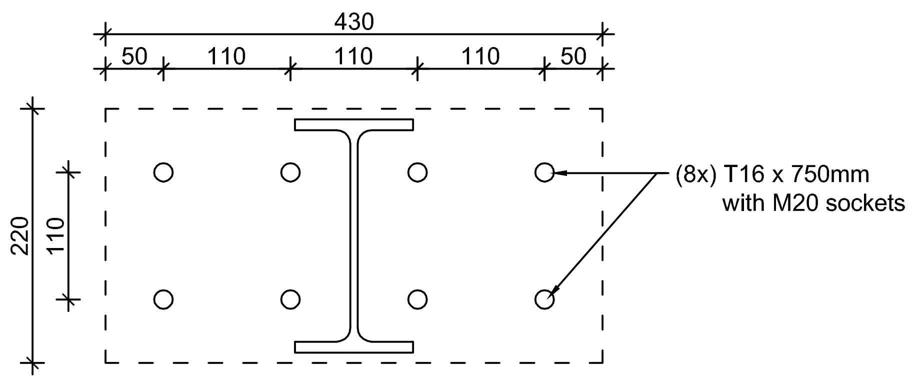


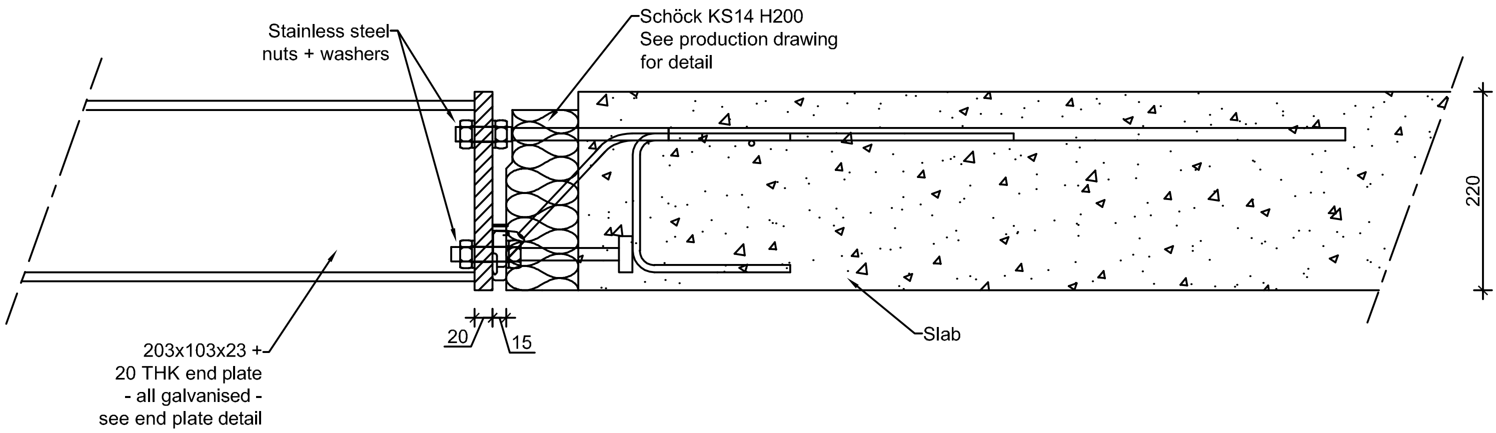
DETAIL 3
PAD CONNECTION 10mm



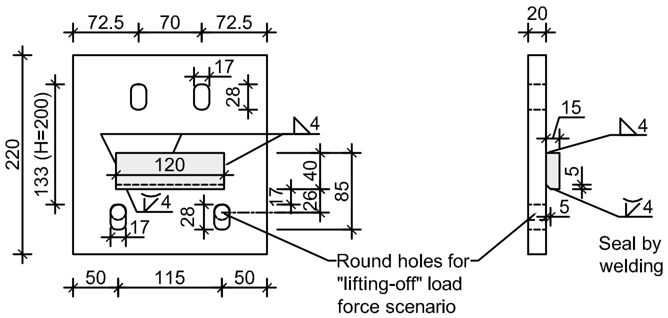
DETAIL 4
PAD CONNECTION 20mm

Rebar nest detail:





SCHÖCK KST: DETAIL 4



END PLATE DETAIL