

Fenestration Calculations

Guideline – SANS 10400-XA²⁰¹¹ & SANS 204²⁰¹¹

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ONLY read together with SANS 10400-XA & SANS 204



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PURPOSE

The purpose of this Guideline is to provide a step-by-step procedure to assist professionals / competent persons with calculating fenestration compliance in terms of SANS 10400-XA:2011 and SANS 204:2011.

The included Example Solution follows the format of this guideline and provides a real world case study to demonstrate the procedure.

FENESTRATION - NATURAL ENVIRONMENTAL CONTROL

Guideline Procedure -

Step 1.

Calculate the nett floor area of each storey of the proposed building measured within the enclosing walls.
(refer to definitions – nett floor area in SANS 10400-XA & SANS 204)

Step 2.

Calculate the total area of the glazing elements of each storey of the proposed building.

Step 3.

Calculate 15% of the nett floor area of each storey of the proposed building.

$$15\% : (\text{nett floor area of storey}) \div (100) \times (15)$$

Step 4.

Determine whether the total area of the glazing elements for each storey is greater than 15% of the nett floor area of such storey.

Where the total area of the glazing elements of a storey do not exceed 15% of the nett floor area of the storey the minimum energy performance requirements for such storey is deemed satisfied.

Where the total area of the glazing elements of a storey is greater than 15% of the nett floor area of the storey the requirements contained in SANS 204 shall be complied with.

Where the requirements of SANS 204 are to be complied with proceed to *step 5*.

Step 5.

Identify the Climatic Zone applicable.
(refer Annex A - SANS 204)

Step 6.

Identify the relevant constants for conductance and SHGC applicable to the identified climatic zone.
(refer table 5 - SANS 204)

Step 7.

Calculate the conductance and solar heat gain (*SHGC*) values that the glazing in each storey shall not exceed.

$$\text{Max. Conductance} : (\text{nett floor area of storey}) \times (\text{constant, } C_U)$$

$$\text{Max. Solar heat gain} : (\text{nett floor area of storey}) \times (\text{constant, } C_{SHGC})$$

Step 8.

Calculate the aggregate conductance value for the glazing in each storey by adding together the conductance of each glazing element.

Where the conductance of a single glazing element is calculated as follows :

Total U-value of glazing element
Table 6 – SANS 204

$$\text{conductance} = (\text{area of glazing element}) \times (U\text{-value of glazing element})$$

The aggregate conductance value of glazing elements is therefore calculated thus

$$(A_1 \times U_1) + (A_2 \times U_2) + (A_3 \times U_3) + (A_4 \times U_4) + (A_5 \times U_5) + \dots$$

Note:

U-values used from table 6 of SANS 204 provide for worst case assessments. The alternative is to use certified *U*-values from manufacturers (combined effect of glass & frame).

Step 9.

Calculate the aggregate *SHGC* value for the glazing in each storey by adding together the *SHGC* of each glazing element.

Where the *SHGC* of a single glazing element is calculated as follows:

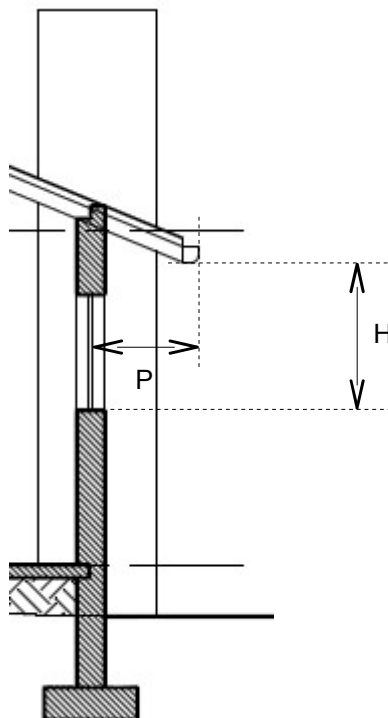
SHGC-value of glazing element
Table 6 – SANS 204

$$SHGC = (\text{area of glazing element}) \times (SHGC\text{-value of glazing element}) \times (\text{solar exposure factor for the glazing element})$$

E-value of glazing element
Annex C – SANS 204

In order to determine the applicable solar exposure factor for a glazing element in a storey the following additional information is required for the glazing element :

- the orientation sector of the glazing element
(refer Fig.1 – SANS 204)
- the horizontal length of the shading element (P) that casts a shadow onto the glazing element per storey measured from the face of the glass
(refer sec. 4.3.5. Shading – SANS 204)
- the vertical height (H) from the base of the glazing element to the underside of the shading element used in measuring (P)
(refer sec. 4.3.5. Shading – SANS 204)



Calculate the value of P/H per glazing element to determine the applicable solar exposure factor :

$$P/H = (\text{horizontal projection (P)}) \div (\text{vertical height (H)})$$

Determine the solar exposure factor (E) based upon the P/H value calculated and orientation of the glazing element for the applicable climatic zone.

(refer Annex C – SANS 204)

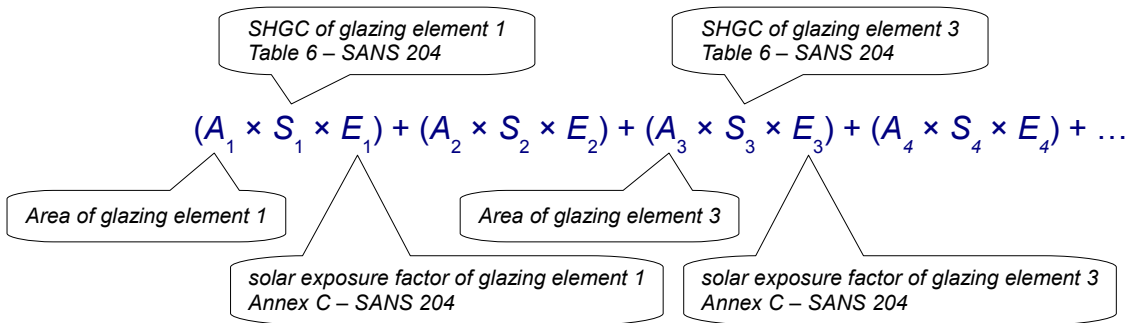
Upon determining the solar exposure factor the SHGC of the single glazing element can be calculated as follows:

SHGC-value of glazing element
Table 6 – SANS 204

$$SHGC = (\text{area of glazing element}) \times (\text{SHGC-value of glazing element}) \times (\text{solar exposure factor for the glazing element})$$

E-value of glazing element
Annex C – SANS 204

The aggregate *SHGC* value of glazing elements is therefore calculated thus :



Step 10.

Determine whether the maximum permitted conductance and maximum *SHGC* for each storey has not been exceeded by comparing the values calculated in *step 8* and *step 9* against the maximum permitted values calculated in *step 7* for conductance and *SHGC*.

Where

(aggregate conductance per storey)
is less than or equal to
(max. conductance permissible)

and

(aggregate *SHGC* per storey)
is less than or equal to
(max. *SHGC* permissible)

the glazing proposed satisfies the requirements of SANS 204 and SANS 10400-XA.

Where

(aggregate conductance per storey)
is greater than
(max. conductance permissible)

and / or

(aggregate *SHGC* per storey)
is greater than
(max. *SHGC* permissible)

the glazing proposed does not satisfy the requirements of SANS 204 and SANS 10400-XA.

Step 11.

Where the glazing per storey proposed does not satisfy the requirements of SANS 204 reconsider the following aspects, individually or in combination with one another:

- (a) framing system;
- (b) glazing material;
- (c) size of glazed elements;
- (d) extent of shading to glazed elements;
- (e) orientation of glazed elements, and

recalculate the aggregate conductance and *SHGC* per storey according to *step 8 and step 9*.

Repeat *step 8* and *step 9* after each adjustment of aspects in *step 11 (a)-(e)* above until the requirements of SANS 204 are satisfied with respect to conductance and *SHGC*.

Step 12.

Where a centrally controlled artificial ventilation or air conditioning system is incorporated into the building proposal, proceed to *step 13*.

Note:

To ensure the future installation of a centrally controlled artificial ventilation or air conditioning system does not compromise the compliance designed into a building, it is suggested that the fenestration calculations for buildings with centrally controlled artificial ventilation or air conditioning systems is undertaken.

FENESTRATION - ARTIFICIAL ENVIRONMENTAL CONTROL

Procedure -

Step 13.

Calculate the façade area of each storey of the proposed building for each orientation sector.
(refer to figure 1 – SANS 204)

façade area
Definition - SANS 204

façade area : (length of façade) x (height of storey)

Step 14.

Identify the relevant energy index applicable to the identified climatic zone.
(refer table 7 - SANS 204)

Step 15.

Calculate the allowance that the aggregate air-conditioning energy value per orientation sector, per storey shall not exceed.

Energy index
Table 7 - SANS 204

Max. Allowance : (façade area) x (energy index)

Note:

Necessity to calculate the façade area relates only to the façade containing fenestration.

However, should a fenestration element require relocation within the storey to satisfy SANS 204 for artificial environmental control, the need to return to step 13 is avoided where ALL the facade areas are calculated in the first instance.

Step 16.

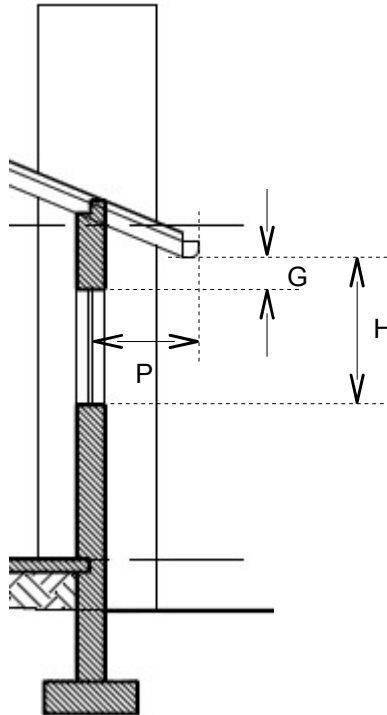
Calculate the aggregate air-conditioning energy value of the façade per orientation sector, per storey by adding together the air-conditioning energy value of each glazing element.

However, in order to determine the applicable energy constants, heating and cooling shading multipliers for a glazing element in a storey, the following additional information is required for the glazing element :

- the orientation of the glazing element
(refer Fig.1 – SANS 204)
- the horizontal length of the shading element (P) that casts a shadow onto the glazing element per storey measured from the face of the glass

- the vertical height (G) from the head of the glazing element to the underside of the shading element used in measuring (P)
(refer sec. 4.3.5. Shading – SANS 204)
- the vertical height (H) from the base of the glazing element to the underside of the shading element used in measuring (P)
(refer sec. 4.3.5. Shading – SANS 204)

Determine the applicable energy constants C_A , C_B & C_C for the glazing elements per storey and orientation sector
(refer Table D1 of Annex D – SANS 204)



Determine the value of G and calculate the value of P/H for each glazing elements to assist with determining the heating and cooling shading multipliers :

G = vertical height from head of the glazing element to underside of shading element

P/H = (horizontal projection (P)) ÷ (vertical height (H))

Determine the applicable heating shading multiplier for the glazing elements per storey, per orientation sector appropriate to the P/H value and within the range of the G value of glazing element.
(refer Annex D – SANS 204)

Similarly determine the applicable cooling shading multiplier for the glazing elements per storey, per orientation sector appropriate to the P/H value and within the range of the G value of glazing element.
(refer Annex D – SANS 204)

Calculate the air-conditioning energy value of a single glazing element as follows:

Add the results of

energy constant A of glazing element
Table D1 Annex D – SANS 204

heating shading multiplier of glazing element
Table D2 Annex D – SANS 204

$$(\text{energy constant}_A) \times (\text{heating shading multiplier}) \quad (1)$$

and

energy constant B of glazing element
Table D1 Annex D – SANS 204

cooling shading multiplier of glazing element
Table D3 Annex D – SANS 204

$$(\text{energy constant}_B) \times (\text{cooling shading multiplier}) \quad (2)$$

Multiply the result of formula (1) + (2) by

SHGC-value of glazing element
Table 6 – SANS 204

$$(\text{SHGC-value of glazing element}) \quad (3)$$

Multiply

energy constant C of glazing element
Table D1 Annex D – SANS 204

Total U-value of glazing element
Table 6 – SANS 204

$$(\text{energy constant}_C) \times (\text{U-value of glazing element}) \quad (4)$$

Add the result of formula (3) + (4) and multiply the result thereof by

$$(\text{area of glazing element}) \quad (5)$$

The aggregate air-conditioning energy value of the façade per orientation sector, per storey is therefore calculated thus :

heating shading multiplier of glazing element 1
Annex D – SANS 204

Total U-value of glazing element 1
Table 6 – SANS 204

SHGC of glazing element 1
Table 6 – SANS 204

cooling shading multiplier of glazing element 1
Annex D – SANS 204

$$A_1 [S_1 (C_A \times S_{H1} + C_B \times S_{C1}) + C_C \times U_1] + A_2 [S_2 (C_A \times S_{H2} + C_B \times S_{C2}) + C_C \times U_2] + \dots$$

Area of glazing element 1

energy constant B of glazing element 1
Table D1 Annex D – SANS 204

energy constant A of glazing element 1
Table D1 Annex D – SANS 204

energy constant C of glazing element 1
Table D1 Annex D – SANS 204

Step 17.

Determine whether the allowance per orientation sector, per storey has not been exceeded by comparing the values calculated in *step 16* against the allowance values calculated in *step 15*.

Where

(aggregate air-conditioning energy value of the
façade per orientation sector, per storey)
is less than or equal to
(allowance value)

the glazing proposed satisfies the requirements of SANS 204 and SANS 10400-XA.

Where

(aggregate air-conditioning energy value of the
façade per orientation sector, per storey)
is greater than
(allowance value)

the glazing proposed does not satisfy the requirements of SANS 204 and SANS 10400-XA.

Step 18.

Where the glazing per storey proposed does not satisfy the requirements of SANS 204 reconsider the following aspects, individually or in combination with one another:

- (a) framing system;
- (b) glazing material;
- (c) size of glazed elements;
- (d) extent of shading to glazed elements;
- (e) orientation of glazed elements, and

recalculate the aggregate air-conditioning energy value of the façade per orientation sector, per storey according to *step 16*.

Repeat *step 16* after each adjustment of aspects in step 18 (a)-(e) until the requirements of SANS 204 are satisfied with respect to the air-conditioning energy values.

Note:

Changes made to fenestration to achieve compliance with artificial environmental control may require the re-evaluation of calculations related to natural environmental control.

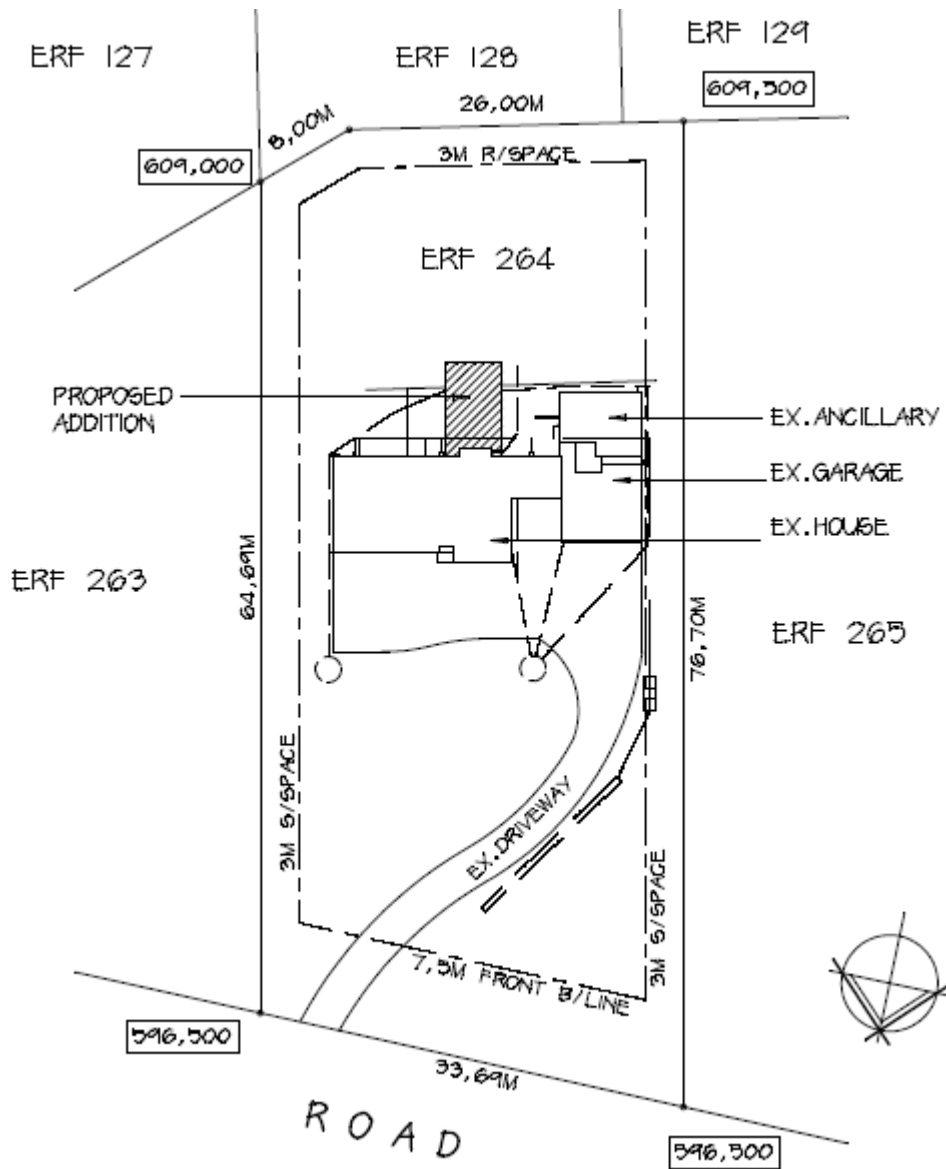
Example - Solution

ADDITION / EXTENSION TO DWELLING

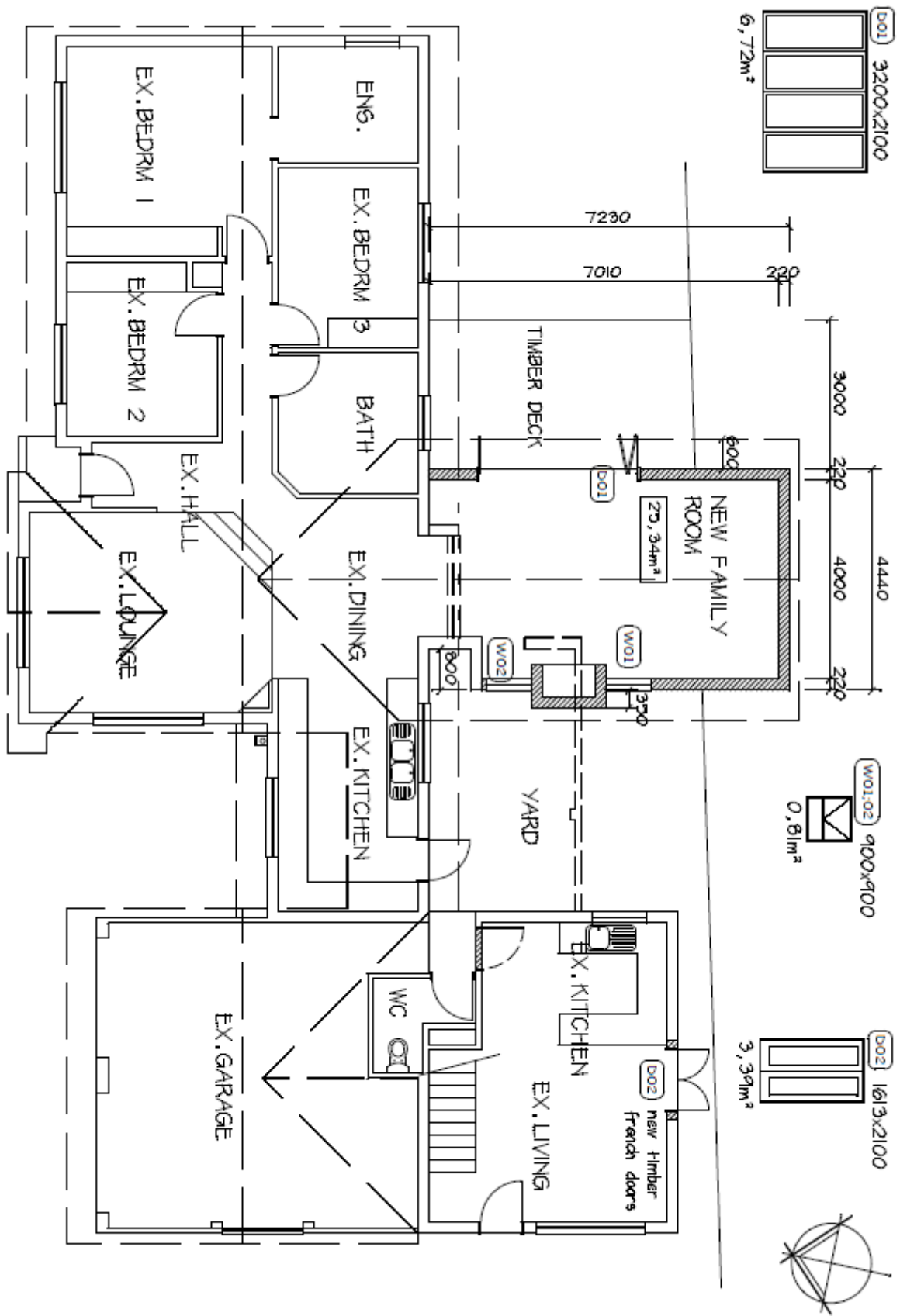
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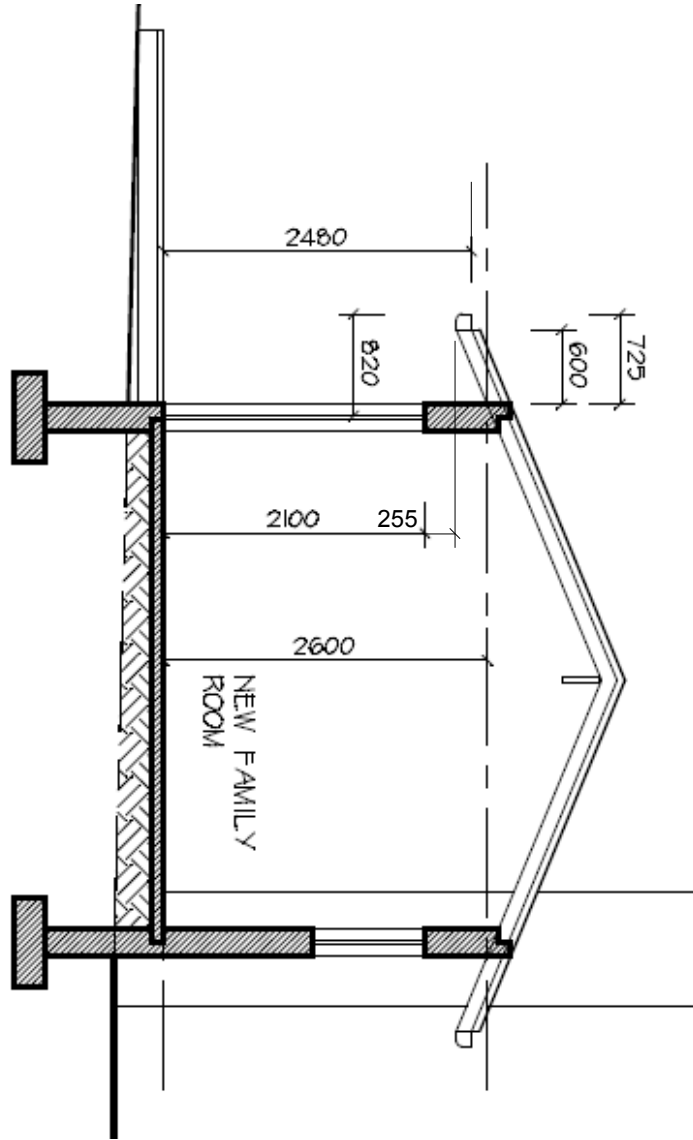
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◎ SECTION

FENESTRATION - NATURAL ENVIRONMENTAL CONTROL

[Note: In this example various constant values from the tables annexed to SANS 204 have been derived through interpolation.]

Step 1.

Nett floor area : 25.34 m²

Step 2.

Total area of glazing :	D01 - 6.72 m ²
	W01 - 0.81 m ²
	W02 - 0.81 m ²
	<hr/>
Total :	8.34 m ²

Step 3.

15 % of nett floor area :

$$(25.34 \text{ m}^2 \div 100) \times 15 = 3.80 \text{ m}^2$$

Step 4.

Glazing area to nett floor area :

glazing area :	8.34 m ²
nett floor area :	3.80 m ²
glazing area >	nett floor area

Glazing is greater than 15 % of nett floor area of proposal therefore calculation i.t.o. SANS 204 is required.

Step 5.

Climatic zone : Zone 5

Step 6.

Constants for conductance and SHGC

Conductance (C _U) :	1.4
SHGC (C _{SHGC}) :	0.11

Step 7.

Max. Conductance : (nett floor area of storey) x (constant, C_U)

$$\text{Max. Conductance : } 25.34 \text{ m}^2 \times 1.4 = 35.476$$

Max. Solar heat gain : (nett floor area of storey) x (constant, C_{SHGC})

$$\text{Max. Solar heat gain : } 25.34 \text{ m}^2 \times 0.11 = 2.787$$

Step 8.

Glazing elements : Timber with clear glass

Aggregate conductance:

$$(A_1 \times U_1) + (A_2 \times U_2) + (A_3 \times U_3)$$
$$(6.72 \text{ m}^2 \times 5.6) + (0.81 \text{ m}^2 \times 5.6) + (0.81 \text{ m}^2 \times 5.6)$$
$$= (37.632) + (4.536) + (4.536)$$
$$= \underline{46.704}$$

Step 9.

$P/H = (\text{horizontal projection (P)}) \div (\text{vertical height (H)})$

$$D01 : P/H = 0.82 / 2.355 = 0.348$$

$$W01 : P/H = 0.82 / 1.155 = 0.710$$

$$W02 : P/H = 0.82 / 1.155 = 0.710$$

Therefore solar exposure factor (E)

$$D01 : P/H = 0.35 \text{ therefore } E = 0,84$$

$$W01 : P/H = 0.70 \text{ therefore } E = 0,62$$

$$W02 : P/H = 0.70 \text{ therefore } E = 0,62$$

Aggregate SHGC:

$$(A_1 \times S_1 \times E_1) + (A_2 \times S_2 \times E_2) + (A_3 \times S_3 \times E_3)$$
$$(6.72 \text{ m}^2 \times 0.77 \times 0,84) + (0.81 \text{ m}^2 \times 0.77 \times 0,62) + (0.81 \text{ m}^2 \times 0.77 \times 0,62)$$
$$= (4.346) + (0.387) + (0.387)$$
$$= \underline{5.12}$$

Step 10.

Max. Conductance permitted : 35.476 (Step 7)

Max. Solar heat gain permitted : 2.787 (Step 7)

Aggregate conductance achieved : 46.704 (Step 8)

Aggregate SHGC achieved : 5.12 (Step 9)

Achieved conductance > permitted conductance

$$46.704 > 35.476 = \text{FAIL}$$

Achieved SHGC > permitted solar heat gain

$$5.12 > 2.787 = \text{FAIL}$$

Possible Solution 1

Step 8-s1.

Glazing elements : Timber with double glazed tinted glass

Aggregate conductance:

$$\begin{aligned} & (A_1 \times U_1) + (A_2 \times U_2) + (A_3 \times U_3) \\ & (6.72 \text{ m}^2 \times 3.0) + (0.81 \text{ m}^2 \times 3.0) + (0.81 \text{ m}^2 \times 3.0) \\ & = (20.160) + (2.430) + (2.430) \\ & = \underline{25.020} \end{aligned}$$

Step 9-s1.

$P/H = (\text{horizontal projection (P)}) \div (\text{vertical height (H)})$

$$D01 : P/H = 0.82 / 2.355 = 0.348$$

$$W01 : P/H = 0.82 / 1.155 = 0.710$$

$$W02 : P/H = 0.82 / 1.155 = 0.710$$

Therefore solar exposure factor (E)

$$D01 : P/H = 0.35 \text{ therefore } E = 0,84$$

$$W01 : P/H = 0.70 \text{ therefore } E = 0,62$$

$$W02 : P/H = 0.70 \text{ therefore } E = 0,62$$

Aggregate SHGC:

$$\begin{aligned} & (A_1 \times S_1 \times E_1) + (A_2 \times S_2 \times E_2) + (A_3 \times S_3 \times E_3) \\ & (6.72 \text{ m}^2 \times 0.56 \times 0,84) + (0.81 \text{ m}^2 \times 0.56 \times 0,62) + (0.81 \text{ m}^2 \times 0.56 \times 0,62) \\ & = (3.161) + (0.281) + (0.281) \\ & = \underline{3.723} \end{aligned}$$

Step 10-s1.

Max. Conductance permitted : 35.476 (Step 7)

Max. Solar heat gain permitted : 2.787 (Step 7)

Aggregate conductance achieved : 25.020 (Step 8-s1)

Aggregate SHGC achieved : 3.723 (Step 9-s1)

Achieved conductance < permitted conductance

$$25.020 < 35.476 = \text{ACCEPTABLE}$$

Achieved SHGC > permitted solar heat gain

$$3.723 > 2.787 = \text{FAIL}$$

Step 9-s1 rev1.

Glazing elements : Timber with double glazed tinted glass

To achieve SHGC compliance further consider:

(a) additional shading of sliding / folding door (1.8 m awning / verandah);

$$P/H = (\text{horizontal projection (P)}) \div (\text{vertical height (H)})$$

$$D01 : P/H = 1.80 / 2.355 = 0.764$$

$$W01 : P/H = 0.82 / 1.155 = 0.710$$

$$W02 : P/H = 0.82 / 1.155 = 0.710$$

Therefore solar exposure factor (E)

$$D01 : P/H = 0.76 \text{ therefore } E = 0,59$$

$$W01 : P/H = 0.70 \text{ therefore } E = 0,62$$

$$W02 : P/H = 0.70 \text{ therefore } E = 0,62$$

Aggregate SHGC:

$$(A_1 \times S_1 \times E_1) + (A_2 \times S_2 \times E_2) + (A_3 \times S_3 \times E_3)$$

$$\begin{aligned} & (6.72 \text{ m}^2 \times 0.56 \times 0,59) + (0.81 \text{ m}^2 \times 0.56 \times 0,62) + (0.81 \text{ m}^2 \times 0.56 \times 0,62) \\ & = (2.220) + (0.281) + (0.281) \\ & = \underline{2.782} \end{aligned}$$

Step 10-s1 rev1.

Max. Conductance permitted : 35.476 (Step 7)

Max. Solar heat gain permitted : 2.787 (Step 7)

Aggregate conductance achieved : 25.020 (Step 8-s1)

Aggregate SHGC achieved : 2.782 (Step 9-s1 rev1)

Achieved conductance < permitted conductance

$$25.020 < 35.476 = \text{ACCEPTABLE}$$

Achieved SHGC < permitted solar heat gain

$$2.782 < 2.787 = \text{ACCEPTABLE}$$

Possible Solution 2

Step 8-s2.

Glazing elements : Timber with single clear glass

Aggregate conductance:

$$\begin{aligned} & (A_1 \times U_1) + (A_2 \times U_2) + (A_3 \times U_3) \\ & (6.72 \text{ m}^2 \times 5.6) + (0.81 \text{ m}^2 \times 5.6) + (0.81 \text{ m}^2 \times 5.6) \\ & = (37.632) + (4.536) + (4.536) \\ & = \underline{46.704} \end{aligned}$$

Step 9-s2.

$P/H = (\text{horizontal projection (P)}) \div (\text{vertical height (H)})$

$$\begin{aligned} \text{D01 : } P/H &= 0.82 / 2.355 = 0.348 \\ \text{W01 : } P/H &= 0.82 / 1.155 = 0.710 \\ \text{W02 : } P/H &= 0.82 / 1.155 = 0.710 \end{aligned}$$

Therefore solar exposure factor (E)

$$\begin{aligned} \text{D01 : } P/H &= 0.35 \text{ therefore } E = 0,84 \\ \text{W01 : } P/H &= 0.70 \text{ therefore } E = 0,62 \\ \text{W02 : } P/H &= 0.70 \text{ therefore } E = 0,62 \end{aligned}$$

Aggregate SHGC:

$$\begin{aligned} & (A_1 \times S_1 \times E_1) + (A_2 \times S_2 \times E_2) + (A_3 \times S_3 \times E_3) \\ & (6.72 \text{ m}^2 \times 0.77 \times 0,84) + (0.81 \text{ m}^2 \times 0.77 \times 0,62) + (0.81 \text{ m}^2 \times 0.77 \times 0,62) \\ & = (4.346) + (0.387) + (0.387) \\ & = \underline{5.21} \end{aligned}$$

Step 10-s2.

Max. Conductance permitted : 35.476 (Step 7)
Max. Solar heat gain permitted : 2.787 (Step 7)

Aggregate conductance achieved : 46.704 (Step 8-s2)
Aggregate SHGC achieved : 5.21 (Step 9-s2)

Achieved conductance > permitted conductance
 $46.704 > 35.476 = \text{FAIL}$

Achieved SHGC > permitted solar heat gain
 $5.21 > 2.787 = \text{FAIL}$

Step 8-s2 rev1.

Glazing elements : Timber with single clear glass

To achieve SHGC compliance further consider:

- a) additional shading of sliding / folding door (1.9 m awning / verandah);
- b) omission of W01 & 02

Therefore aggregate conductance (door only):

$$(A_1 \times U_1)$$

$$(6.72 \text{ m}^2 \times 5.6) \\ = \underline{37.632}$$

Step 9-s2 rev1.

$P/H = (\text{horizontal projection (P)}) \div (\text{vertical height (H)})$

$$D01 : P/H = 1.9 / 2.355 = 0.807$$

Therefore solar exposure factor (E)

$$D01 : P/H = 0.81 \text{ therefore } E = 0,53$$

Aggregate SHGC (door only):

$$(A_1 \times S_1 \times E_1)$$

$$(6.72 \text{ m}^2 \times 0.56 \times 0,53) \\ = \underline{1.994}$$

Step 10-s2 rev1.

Max. Conductance permitted : 35.476 (Step 7)

Max. Solar heat gain permitted : 2.787 (Step 7)

Aggregate conductance achieved : 37.632 (Step 8-s2 rev1)

Aggregate SHGC achieved : 1.994 (Step 9-s2 rev1)

Achieved conductance > permitted conductance

$$37.632 > 35.476 = \text{FAIL}$$

Achieved SHGC < permitted solar heat gain

$$1.994 < 2.787 = \text{ACCEPTABLE}$$

Step 8-s2 rev2.

Glazing elements : Timber with single clear glass

Further to solution proposed in *Step 8s2-rev1* consider:

a) reducing width of sliding / folding door to 3.0 m x 2.1 m;

Therefore aggregate conductance (door only):

$$(A_1 \times U_1)$$

$$(6.30 \text{ m}^2 \times 5.6) \\ = \underline{35.280}$$

Step 9-s2 rev2.

$$P/H = (\text{horizontal projection (P)}) \div (\text{vertical height (H)})$$

$$D01 : P/H = 1.9 / 2.355 = 0.807$$

Therefore solar exposure factor (E)

$$D01 : P/H = 0.81 \text{ therefore } E = 0,53$$

Aggregate SHGC (door only):

$$(A_1 \times S_1 \times E_1)$$

$$(6.30 \text{ m}^2 \times 0.77 \times 0,53) \\ = \underline{2.571}$$

Step 10-s2 rev2.

Max. Conductance permitted : 35.476 (Step 7)

Max. Solar heat gain permitted : 2.787 (Step 7)

Aggregate conductance achieved : 35.280 (Step 8-s2 rev2)

Aggregate SHGC achieved : 2.571 (Step 9-s2 rev2)

Achieved conductance < permitted conductance

$$35.280 < 35.476 = \text{ACCEPTABLE}$$

Achieved SHGC < permitted solar heat gain

$$2.571 < 2.787 = \text{ACCEPTABLE}$$

FENESTRATION - ARTIFICIAL ENVIRONMENTAL CONTROL

[Note: In this example various constant values from the tables annexed to SANS 204 have been derived through interpolation.]

Step 13.

Total façade area:

$$\begin{aligned} \text{East sector} & - 7.23 \times 2.8 & = 20.24 \text{ m}^2 \\ \text{South sector} & - (4.44 \times 2.8) + (4.44/2 \times 0.85) + (0.35 \times 2.6) & = 15.23 \text{ m}^2 \\ \text{West sector} & - 7.23 \times 2.8 & = 20.24 \text{ m}^2 \\ \text{North sector} & - (0.8 \times 2.8) + (0.35 \times 2.6) & = 3.15 \text{ m}^2 \end{aligned}$$

Step 14.

Climatic zone: Zone 5 (Step 5)

Index value:

Energy index : 0.180

Step 15.

Max. Allowance : (façade area) x (energy index)

$$\begin{aligned} \text{East sector} & : 20.24 \text{ m}^2 \times 0.18 = 3.643 \\ \text{South sector} & : 15.23 \text{ m}^2 \times 0.18 = 2.741 \\ \text{West sector} & : 20.24 \text{ m}^2 \times 0.18 = 3.643 \\ \text{North sector} & : 3.15 \text{ m}^2 \times 0.18 = 0.567 \end{aligned}$$

Step 16.

Glazing elements : Timber with single clear glass

Energy constants:

East sector :

$$C_A = 0.00 ; C_B = 0.91 ; C_C = 0.02$$

West sector :

$$C_A = 0.00 ; C_B = 0.88 ; C_C = 0.02$$

G = vertical height from head of the glazing element to underside of shading element

$$D01 : 0.255 \text{ m}^2$$

$$W01 : 0.255 \text{ m}^2$$

$$W02 : 0.255 \text{ m}^2$$

P/H = (horizontal projection (P)) ÷ (vertical height (H))

$$D01 : P/H = 0.82 / 2.355 = 0.348 \quad (\text{Step 9})$$

$$W01 : P/H = 0.82 / 1.155 = 0.710$$

$$W02 : P/H = 0.82 / 1.155 = 0.710$$

Step 16.

Heating shading multipliers:

East sector : $S_H = 1.00$

West sector : $S_H = 1.00$

Cooling shading multiplier:

East sector : $S_C = 0.90$

West sector : $S_C = 0.70$

Aggregate air-conditioning energy value:

East sector :

$$A_1 [S_1 (C_A \times S_{H1} + C_B \times S_{C1}) + C_C \times U_1]$$

$$D01 = 6.72 \text{ m}^2 [0.77(0.00 \times 1.00 + 0.91 \times 0.90) + 0.02 \times 5.6] = 4.99$$

West sector :

$$A_2 [S_2 (C_A \times S_{H2} + C_B \times S_{C2}) + C_C \times U_2] +$$

$$A_3 [S_3 (C_A \times S_{H3} + C_B \times S_{C3}) + C_C \times U_3]$$

W01+W02

$$0.81 \text{ m}^2 [0.77(0.00 \times 1.00 + 0.88 \times 0.70) + 0.02 \times 5.6] + \\ 0.81 \text{ m}^2 [0.77(0.00 \times 1.00 + 0.88 \times 0.70) + 0.02 \times 5.6] = 0.950$$

Step 17.

East sector :

Max. Allowance : 3.643 (Step 15)

Aggregate energy value : 4.99 (Step 16)

Aggregate energy value > Max. Allowance

$$4.99 > 3.643 = \text{FAIL}$$

West sector :

Max. Allowance : 3.643 (Step 15)

Aggregate energy value : 0.950 (Step 16)

Aggregate energy value < Max. Allowance

$$0.950 < 3.643 = \text{ACCEPTABLE}$$

Possible Solution 1

Step 16-s1.

Glazing elements : Timber with double glazed tinted glass

Aggregate air-conditioning energy value:

East sector :

$$A_1 [S_1 (C_A \times S_{H1} + C_B \times S_{C1}) + C_C \times U_1]$$

$$D01 = 6.72 \text{ m}^2 [0.56(0.00 \times 1.00 + 0.91 \times 0.90) + 0.02 \times 3.0] = 3.485$$

West sector :

$$A_2 [S_2 (C_A \times S_{H2} + C_B \times S_{C2}) + C_C \times U_2] +$$
$$A_3 [S_3 (C_A \times S_{H3} + C_B \times S_{C3}) + C_C \times U_3]$$

W01+W02

$$0.81 \text{ m}^2 [0.56(0.00 \times 1.00 + 0.88 \times 0.70) + 0.02 \times 3.0] +$$
$$0.81 \text{ m}^2 [0.56(0.00 \times 1.00 + 0.88 \times 0.70) + 0.02 \times 3.0] = 0.656$$

Step 17-s1.

East sector :

Max. Allowance : 3.643 (Step 15)
Aggregate energy value : 3.485 (Step 16-s1)

Aggregate energy value < Max. Allowance
 $3.485 < 3.643 = \text{ACCEPTABLE}$

West sector :

Max. Allowance : 3.643 (Step 15)
Aggregate energy value : 0.656 (Step 16-s1)

Aggregate energy value < Max. Allowance
 $0.656 < 3.643 = \text{ACCEPTABLE}$