Cladding Annex 1 – Cladding Thickness

The following section has been adapted from the Information Paper on BS 8298 prepared by the Stone Federation. It is important that all calculations are checked by a suitably qualified engineer.

Introduction

The panel thickness should be determined at an early stage of design (stage C or D), so as to influence key decisions relating to the façade setting out and wall construction make up.

There are two modes of failure for the stone panel that relate to the stone thickness;

- breaking due to the lateral load
- breaking at the fixing point

Ideally the thickness of Portland stone cladding needs to be determined by **calculation** as per the methods stated in BS 8298 Section 4 Part 2, but it can also be assessed by using the tables in the new **Annex A** in Part 2. These tables give recommended thickness based on satisfactory past experience so will tend to result in thicker stones which may be suitable for smaller projects, but may result in unnecessary stone (cost and weight) for larger projects.

A. Portland Stone Thickness Determined by Calculation

Assuming the calculation to assess the most appropriate thickness is completed, there are various factors that need to be considered and information that is required:

1) the lateral load on the building
2) the fixing system
3) the panel size
4) the stone's technical properties:
   a) the flexural strength
   b) the breaking load at dowel hole
5) the factor of safety to be used

1) The lateral load on the building

This wind load can be calculated using the methods and factors given in BS 6399, which will provide an accurate figure for the lateral load on the stone panels. If for whatever reason the project specific lateral load calculation cannot be completed then the Table 1 in Part 2 of BS 8298 can be used instead. This pressure in N/m^{-2} (q) is used in the calculation for the thickness of the cladding. Table 2 from BS 8298

CLASS	***LOAD***	***BRIEF DESCRIPTION***
Low wind load environment	*1500 $N \cdot m^{-2}$*	*Sheltered environment such as the lower floors of a building in a central urban area, e.g. Central Manchester*
Medium wind load environment	*2250 $N \cdot m^{-2}$*	*A more exposed environment such as the higher floors of a tall building or a more exposed location, e.g. Canary Wharf, London*
High wind load environment	*3000 $N \cdot m^{-2}$*	*An exposed environment such as a coastal location*

2) The Fixing System

The support of the stone will impact on the thickness calculation. Normally it is assumed that it will be four 6mm dowels in the longer lengths, the top and the bottom edges of the stone panel. From the location of the fixings the greatest panel span, the maximum distance between the fixings measured parallel to the side of the panel, can be measured / calculated. The number of fixings forms part of the strength at fixing point calculation.

3) Panel Size

The panel size will affect the calculation as the bigger the panel the greater the lateral load and the more force is applied to the stone and the fixings. The panel sizes in mm are used in the thickness calculation; b is the width and L the span.

4) Stone Technical Properties

It is vital that the stone selected has adequate and current technical data results, tested to the correct Euro-code testing standard with a CE certificate. Albion Stone's data sheets / certificates provide the figures for the flexural strength and the breakable load at dowel hole (which is dependent on the thickness) as a mean figure or a lowest expected value (LEV) and these figures are based on a large number of test results over a long period which provides the most reliable results. Portland Stone like most porous stone will suffer some strength reduction when tested wet, so the wet test results will provide the most conservative strength values, these results are available on request. The stone flexural strength (Dfb) will be used for the thickness calculation and the dowel pull out figures for the strength at fixing calculation.

5) Factor of Safety

It is important to understand the impact of mean or LEV and dry or wet results and the previous proven service record of the proposed stone on the appropriate Factor of Safety to be used. This flexural safety factor (FSF) is used as part of the calculation for the thickness.

To calculate the correct thickness of the stone, the following properties need to be assessed: i) strength of the stone slab against the lateral load and the ii) strength at the fixing point.

i) Calculation for the thickness of the stone slab compared to the lateral loading on the stone.

$W = (q \times b) / 10^6$

W = load in N/mm

q = pressure in N/m^{-2}

b = width in mm

$Mf = (W \times L^2) / 8$

Mf = failure moment in N.mm

W = load in N/mm

L = span in mm

fb = Dfb / FSF

fb = flexural stress in MPa

Dfb = design flexural stress of the stone in MPa

FSF = flexural safety factor

S = Mf / Fb

S = section modulus in mm^3

Mf = failure moment in N.mm

f b = flexural stress in MPa

$$d = \sqrt{\frac{6S}{b}}$$

d = thickness of the stone in mm

S = section modulus in mm^3

b = width in mm

ii) <u>Calculation to check the Strength at fixing point</u>

Wind Load $N \cdot m^{-2}$ (see Table 2) x Panel Area m^2 (b = width in mm x L = span in mm)/ 10^6 x Factor of Safety (see section 4) = Lateral load on the stone panel

Lateral Load on the Stone Panel ÷ Number of Fixings = Loading on each Fixing

The loading on each fixing needs to be compared with the result for the breaking load at dowel hole for the appropriate thickness. The loading needs to be significantly less than the strength.

Example of Stone Thickness Determined by Calculation

Below is an example of the stone thickness calculation using Portland Jordans Basebed with a panel size of 900mm long (l) and 600mm high (b) and 4 dowels fixings supporting the stone. It is assumed that the building is in Central London, but a wind load calculation has not been completed so the figures in Table 2 have been used for a low wind environment so the load is 1500 N·m⁻² (q). The mean flexural strength figure of 6.78Mpa (Dfb) has been used and a factor of safety of 6 (FSF) for the lateral loading and strength at fixing calculations.

1. *Calculation for the thickness of the stone slab compared to the lateral loading on the stone*

W = (q x b) / 10^6
W = (1500 x 600) / 10^6 = 0.9

Mf = (W x L^2) / 8
Mf = (0.9 x 900^2) / 8 = 91.125

fb = Dfb / FSF
fb = 6.78 / 6 = 1.13

S = Mf / Fb
S = 91.125 / 1.13 = 80,642

$$d = \sqrt{\frac{6S}{b}}$$

d = √6 x 80,642 / 600 = 28.4

A Portland Jordans Basebed panel of 900mm x 600mm in Central London needs to be 28.4mm (say 30mm) thick to resist lateral loading.

2. *Calculation to check the Strength at fixing point*

Wind Load N·m⁻² (see Table 2) x Panel Area m² (b = width in mm x L = span in mm)/ 10^6 x Factor of Safety (see section 4) = Lateral load on the stone panel

Lateral load on the stone panel = 1500 x (600 x 900)/ 10^6 x 6 = 4,860 N

Lateral Load on the Stone Panel ÷ Number of Fixings = Loading on each Fixing

Loading on each Fixing = 4,860 / 4 = 1,215 N

Using the figure from the Technical data sheet Portland Jordans Basebed Dowel Pull tests show that;

- *40mm the mean breaking load is 1,138 N*
- *50mm the mean breaking load is 1,637 N*

Therefore to allow for a significant margin in the fixing loading strength of the Portland Jordan Basebed stone panels of 900mm x 600mm, the thickness needs to be 50mmm.
The calculations show that to resist the lateral loading the thickness needed to be 30mm thick, but to provide a suitable strength at the fixing point the thickness needed to be 50mm. Obviously the greatest thickness figure of 50mm needs to be used.

B. Stone Thickness determined by the tables in Annex A in BS8298

The tables in Annex A of BS 8298 are to be used for stones that have an excellent record of previous use in a similar environment as defined as test Regime 1 in Table 3 Part 1, and also the information in the History of Use section in the Stone Federation's User Guide to BS 8298under section 1 Geology and Samples.
As the stone's flexural strength is the only figure considered apart from the span between fixings, it is vital that the stone selected has adequate and current technical data results tested to the correct Euro-code testing standard with a CE certificate, please see the Portland Stone section: of this website (http://www.albionstone.com/portland-stone/). These data sheets / certificates will provide the figures for the flexural strength either as a mean figure or a lowest expected value (LEV); it is the mean figure that is required for these tables.

Table 1 – Panel thickness for high wind load environments

Greatest span between fixings mm	Panel thickness based on mean flexural strength mm			
	1.00 MPa to 2.99 MPa	**3.00 MPa to 8.99 MPa**	9.00 MPa to 14.99 MPa	> 15.00 MPa
> 300	50	**40**	30	30
300 to 450	70	**50**	30	30
451 to 600	80	**60**	40	30
601 to 750	—	**70**	40	40
751 to 900	—	**80**	50	40

Table 2 – Panel thickness for medium wind load environments

Greatest span between fixings mm	Panel thickness based on mean flexural strength mm			
	1.00 MPa to 2.99 MPa	**3.00 MPa to 8.99 MPa**	9.00 MPa to 14.99 MPa	> 15.00 MPa
> 300	50	**30**	30	30
300 to 450	60	**40**	30	30
451 to 600	70	**50**	40	30
601 to 750	80	**60**	40	30
751 to 900	—	**70**	50	40

Table 3 – Panel thickness for low wind load environments

Greatest span between fixings mm	Panel thickness based on mean flexural strength mm			
	1.00 MPa to 2.99 MPa	**3.00 MPa to 8.99 MPa**	9.00 MPa to 14.99 MPa	> 15.00 MPa
> 300	40	**30**	30	30
300 to 450	50	**40**	30	30
451 to 600	60	**40**	30	30
601 to 750	80	**50**	40	30

751 to 900	—	**60**	40	30