EPFComposite

Design Calculation of Overlay Laminate for : **DN** **1200**

1. Calculate Axial Loading, Qx :

$$Qx = \frac{P \times D}{4}$$ Eq. 8, BS 4994

Where :

P = Design pressure = 1.6 N/mm^2
D = Pipe I.D. = 1177 mm

$$Qx = \frac{1.6 \times 1177}{4}$$

Qx = 470.8 N/mm

Calculate Design Factor, K

k1 = 1.5 for hand lay-up
k2 = 1.2 for long term behavior
k3 = 1.0 for ambient temp.
k4 = 1.1 for cyclic stressing
k5 = 1.1 for post curing procedure

K = 3 x 1.5 x 1.2 x 1.0 x 1.1 x 1.1 = 6.53

Using Design Factor, K = 8

Calculating maximum allowable strain, ε

$$\varepsilon = \frac{UTUS}{Xz \times K}$$

Where :
UTUS = Ultimate tensile unit strength, Table 5, BS 4994
Xz = Unit modulus, Table 5
K = Design Factor

For Woven Roving, WR :

$$\varepsilon = \frac{250}{16000 \times 8}$$

ε = 0.0020

Take the value for woven roving as the design strain, ε_D :

ε_D = 0.0020

Calculate the Strain-limited allowable loading, Us for each reinforcement type :

Us = Xz x ε_D x mz

Where :
mz = mass of reinforcement per unit area = 0.270 kg/m2 for wr270
0.360 kg/m2 for wr360
0.580 kg/m2 for wr580

For WR 270:

Us = 16000 x 0.0020 x 0.270

Us = 8.44 N/mm

For WR 360 :

Us = 16000 x 0.0020 x 0.360

Us = 11.25 N/mm

For WR 580 :

Us = 16000 x 0.0020 x 0.580

Us = 18.13 N/mm

2. Determining the number of layers per reinforcement :

Qx $\leq$ $(Us \times n1)_{270} + (Us \times n2)_{360} + (Us \times n3)_{580}$

Qx $\leq$ (8.44 n) + [11.25 (n-1)] + [18.13 (n-2)]

470.8 37.81 n - 47.5

n = 14 layers wr270 13.70

n - 1 = 13 layers wr360

n - 2 = 12 layers wr580

Total layers = 38 total layers

3. Calculate thickness of overlay laminate , TLAM :

For WR 270:

mwr = 0.270 x 14

mwr = 3.70 kg./m2

t270 = mwr270 x tc

where :
tc = thickness constant for "E" glass csm & wr
= 0.391
tc = thickness constant for resin
= 0.769

t270 = 3.70 x 0.391

t270 = 1.45 mm

For thickness of resin in wr270 : Assume a 50 : 50 glass : resin ratio

mresin270 = mwr / (100-50)/50

where :
glass = 50 %
resin = 50 %

mresin270 = 3.70 kg/m^2

tresin270 = 3.70 x 0.769

tresin270 = 2.85 mm.

TLAMwr 270 = 1.45 + 2.85

TLAMwr 270 = 4.29 mm.

For WR 360 :

mwr = 0.360 x 13

mwr = 4.57 kg./m2

t360 = 4.57 x 0.391

t360 = 1.79 mm

mresin360 = 4.57 kg/m^2

tresin360 = 4.57 x 0.769

tresin360 = 3.52 mm

TLAMwr 360 = 1.79 + 3.52

TLAMwr 360 = 5.31 mm

For WR 580 :

mwr = 0.580 x 12

mwr = 6.79 kg./m2

t580 = 6.79 x 0.391

t580 = 2.65 mm

mresin580 = 6.79 kg./m2

tresin580 = 6.79 x 0.769

tresin580 = 5.22 mm

TLAMwr 580 = 2.65 + 5.22

TLAMwr 580 = 7.9 mm

TLAM = TLAM270 + TLAM360 + TLAM580

TLAM = 4.29 + 5.31 + 7.9

TLAM = 17.48 mm.

To check :

$Qx \leq (Us \times n1)_{270} + (Us \times n2)_{360} + (Us \times n3)_{580}$

470.8 ≤ 115.65 + 142.95 + 212.19

470.8 ≤ 470.80 Therefore: **OK**

4. Calculate the length of overlay laminate, Lj :

$$Lj = \frac{Qa \times Kovl}{\text{Lap Shear Strength}}$$ Eq. 56, BS 4994

Where :
Lj = Length of joint overlay
Qa = Qx = 470.8 N/mm.
Kovl = K = 8
Lap shear Strength : 7

$$Lj = \frac{470.8 \times 8}{7}$$

Lj = 539.00 mm.

Employing the same calculations with the following variables :

DN = Pipe nominal diameter, mm.
I. D. = Pipe internal diameter, mm.
O.D. = Pipe outside diameter, mm.
TLAM = Lamination thickness, mm
Lj = Length of joint lamination, mm.

And the constant value of P = 1.6 N/mm2, as Design Pressure:
We have determined TLAM and Lj for the following pipe sizes as shown in Table 2. below:

Table 2. Overlay Laminate minimum widths and thicknesses

Pipe Size DN	I.D. mm.	O.D mm.	TLAM* mm.	Lj mm.	Design t** mm
150	145	157	2.00	67.00	
200	196	208	4.00	90.00	
250	247	259	5.00	113.00	
300	296	310	5.00	136.00	
400	394	412	7.00	181.00	6.66
500	494	514	9.00	226.00	
600	590	616	10.00	270.00	
700	684	718	15.00	313.00	14.04
800	786	820	15.00	360.00	
1000	980	1024	17.00	449.00	
1200	1179	1228	21.00	539.00	14.48
1400	1371	1432	23.00	627.00	20.58
1600	1572	1636	27.00	719.00	24.43
1800	1781	1845	30.00	815.00	
2000	1974	2044	34.00	903.00	

* using csm450 and wr600

** using the wr glass indicated above

5. Determining the mass of laminate materials :

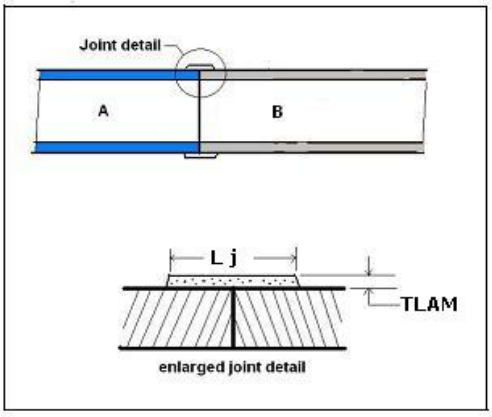

Fig 1. Typical section of butt weld lamination

Where :

OD = 1228 mm.

Lj = 539 mm.

Total Mass of Glass Required:

Tmwr = m270 + m360 + m580 kg/m2

= (3.70 + 4.57 + 6.79) x 3.14 (OD + TLAM) x Lj

= 15.07 x 3.14 x 1.25 x 0.539

Tmwr = 31.76 kg.

Since, glass to resin ratio is 50 : 50 by mass :

Tmresin = 31.76 kg.

Therefore, total mass of materials to be used :

Tmass = 63.51 kg.

Prepared by :

Elias C. Quijano
GRP Specialist
SCE No. 36425