Carbon Fiber Reinforced Polymer (CFRP)

TAPE

Aslan 500

by Hughes Brothers

Aslan 500 Carbon Fiber Reinforced Polymer (CFRP) Tape is used for structural strengthening of concrete, masonry or timber elements using the technique known as “Near Surface Mount” or NSM strengthening.

Benefits of Aslan 500 CFRP Tape

The Benefits of using Aslan 500 CFRP Tape for structural strengthening using the Near Surface Mounted technique include:

- Better bond with the substrate compared with externally bonded FRP systems, means greater utilization of the FRP.
- CFRP Tape arrives with guaranteed physical & mechanical properties.
- Surface preparation issues are minimized.
- After installation, NSM tape is protected from mechanical damage and offers better fire performance than externally bonded systems.
- Strengthening results are superior to externally bonded systems.
- Installation of NSM CFRP Tape is faster and can be done in more diverse weather conditions.

Aslan 500 can be used to remove posted limits on bridges.

Features of Aslan 500 CFRP Tape

Aslan 500 is a 2mm X 16mm “tape” designed specifically for NSM strengthening. It is made from 700ksi, 33Msi carbon fiber, 60% by volume in a Bisphenol Epoxy Vinyl ester resin matrix.

A surface treatment is applied to the wide faces of the CFRP Tape to enhance the bond characteristics when used with structural epoxy adhesives or cementitious latex modified grouts.

The nominal “diameter” or cross sectional area of Aslan 500 is the same as a #2 or 1/4” diameter rod.

It is furnished in continuous lengths in spools that are 250ft (76m) long.


Aslan 500 is dispensed in 250ft lengths similar to a tape measure.

Physical Properties

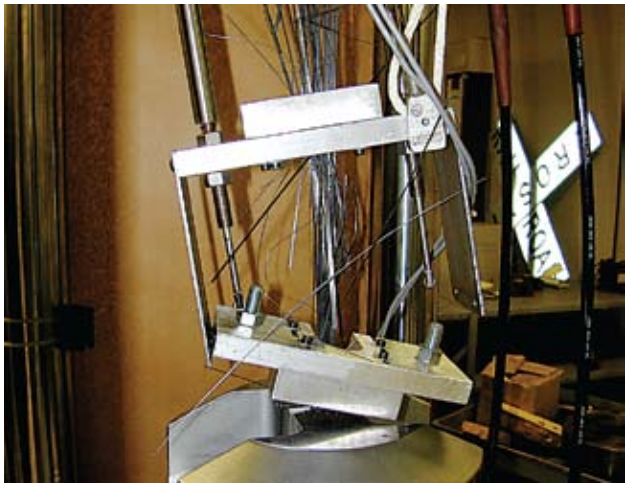
Aslan 500 Designation		Width		Thickness		Cross Sectional Area		Tensile Strength*		Tensile Modulus of of Elasticity		Ultimate Strain
mm	#	*mm*	*in*	*mm*	*in*	*mm^2*	*in^2*	*MPa*	*ksi*	*Gpa*	*psi10^6*	*%*
6 mm	#2	16	0.63	2	.079	31.2	0.05	2068	300	124	18	0.017
10 mm	#3	16	0.63	4.5	.177	71.3	.1104	1965	285	124	18	0.015

Hughes Brothers reserves the right to make improvements in the product and/or process which may result in benefits or changes to some physical-mechanical characteristics. Please refer to our web site at www.hughesbros.com for the most current values. The data contained herein is considered representative of current production and is believed to be reliable and to represent the best available characterization of the product as of December 2008.

Tensile strengths shown are the average minus three standard deviations. Per ACI440, this value is f^*_{fu}, the guaranteed tensile strength.

Tensile Modulus of Elasticity values are the average of a population of test specimens as per ACI440 guidelines.

Aslan 500 CFRP tape being tested



Valid Failure

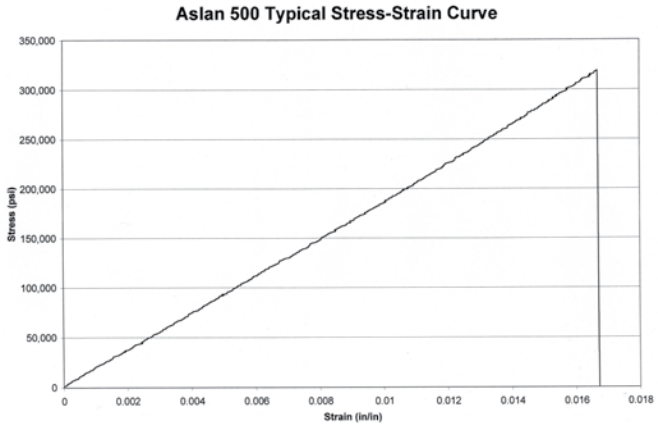
Coefficient of Thermal Expansion:

Transverse Direction ..... 41 to 58 X 10^{-6}/F (74 to 104 X 10^{-6}/C)
Longitudinal Direction... 4 to 0.0 X 10^{-6}/F (-9 to 0.0 X 10^{-6}/C)

Barcol Hardness:

48 - 55 per ASTM D2583

Unlike steel materials, the stress-strain curve of FRP materials is linear elastic to failure.



NSM Design

Structural strengthening using Aslan 500 is based on the principles of ACI440.2R-08 “Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures”. A companion product to Aslan 500 is the Aslan 200 CFRP rebar. Aslan 500 is intended for flat surfaces and is embedded in a saw kerf cut.

Recommended Structural Adhesives include:

BASF (Master Builders) Concresive 1420

DeNeef Enforce CFL Gel

Hilti RE500

Unitex Propoxy 400

NSM Design Example – BASEMENT WALL STRENGTHENING

The following example shows the strengthening of a basement wall subjected to a maxium of 305 lbs per square foot of earth pressure. In this instance, since the earth force will be sustained against the basement wall, the use of CFRP Tape is desirable.

Objective

The design specifications are in compliance with ACI 440.1R-01, hereafter referred to as ACI 440 and ACI 530-02/ASCE 5-02/TMS 402-02, hereafter referred to as ACI 530 reported by the Masonry Standard Joint Committee, and Masonry Designer's Guide (MDG)

Materials

Table 1 presents the properties of concrete masonry, and carbon (CFRP) tapes.

Table 1 – Engineering Properties of Concrete Masonry and FRP Reinforcement

Material	Masonry Compressive Strength f'_m [psi]	Guaranteed Tensile Strength f^*_{fu} [ksi]	Guaranteed Modulus of Elasticity E_f [ksi]
Masonry	2,000	-	-
CFRP Tape	-	300	20,000

Design Considerations

The design of the strengthening follows Allowable Stress Design (ASD). Thus, according to ACI 530 and MDG, the following parameters were computed for the masonry:

$$f_b = \frac{1}{3} f'm = 0.7\ ksi \qquad (1)$$

$$f_v = \sqrt{f'm} = 44.7\ psi$$

$$E_m = 900\, f'm = 1800\ ksi$$

where F_b, F_v and E_m represent allowable compressive strength, shear strength and modulus of elasticity of the masonry, respectively.

The design properties used for the FRP reinforcement are expressed as follow:

$$F_{fu} = C_E f^*_{fu} \qquad (2)$$

$$F_{f\_all} = k \cdot f_{fu}$$

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where f_{fu} and $f_{f\text{-}all}$ are the ultimate design strength and allowable design strength of FRP reinforcement, CE is the environmental reduction factor as reported in ACI 440 (Table 7.1), and k gives the percentage of the ultimate to define the allowable stress of the FRP reinforcement. A value of k equal to 0.3 is used in the case of the CFRP tape in order to avoid premature modes of failure. Design modulus of elasticity of FRP is taken as indicated by the Hughes Brothers. Table 2 summarizes the assumed design properties for FRP.

Table 2 – Design Properties of the FRP Reinforcement

Material	C_E	K	f_{fu} (ksi)	$f_{f\text{-}all}$ (ksi)
CFRP Tape	0.9	0.3	270	81

External Loads

The pressure exerted to the wall by the earth is considered to have a triangular distribution, with the maximum pressure w=305 psf at the bottom of the wall.

Analysis

The structural analysis is carried out considering that the wall is simply supported (see Fig 1).

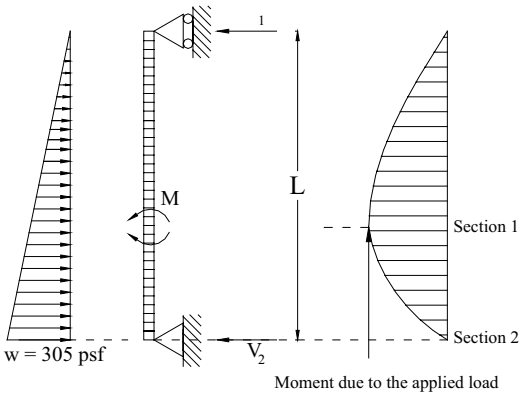

Figure 1 – Simply Supported Beam Used in the Design.

Maximum bending moment is expressed as (Eq. (3)):

$$M_1 = \frac{wL^2}{9\sqrt{3}} \tag{3}$$

Maximum shear force due to the applied load is expressed as (Eq.(4)):

$$V_2 = \frac{wL}{3} \tag{4}$$

The amount of FRP needed to satisfy the load demand is one CFRP Tape every 24 in. This spacing of 24 in. does not exceed the maximum spacing recommended by MDG (four times the wall thickness).

Table 3 – Design of FRP Reinforcement.

Description	(1 CFRP Tape@24")	
	Sec. 1	Sec. 2
Width of the wall, ***b*** [in]	12	12
Thickness of the wall, ***h*** [in]	10	10
FRP Maximum Tensile Stress, f_f [ksi]	64.83	-
Max. Masonry Compressive Stress, f_b [ksi]	0.421	-
Max. Masonry Shear Stress, f_v [psi]	-	7.592(*)

**) Calculated with the maximum shear force (Eq. (2-19), ACI 530)*

A sketch of the reinforcement placed into the masonry blocks is depicted:

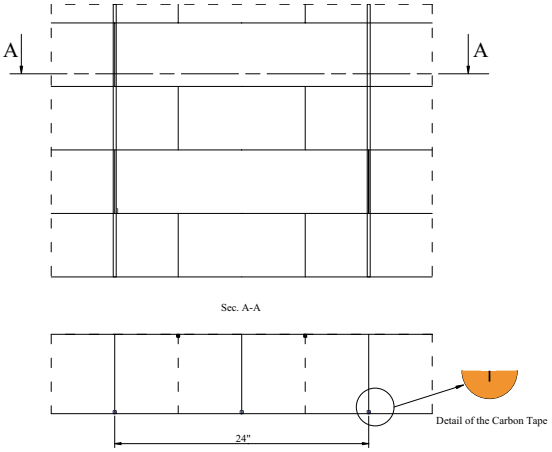

Figure 2 - CFRP Reinforcement Location Detail.

Installation

After assessment of the condition of the existing structure and design by a competent professional, installation of the CFRP Tape is performed according to the following general outline.

1. Using a diamond blade concrete saw or grinder, a groove of 1/4" X 7/8" is cut.
   The use of two diamond blades on the arbor may be necessary to make the 1/4" width cut.
2. The groove is thoroughly cleaned using a vacuum and/or compressed air.
3. The slot is masked to prevent excess adhesive from marring surface.
4. Structural adhesive Gel is filled in the slot. Care should be made to avoid entrapped air voids.
5. The CFRP Tape is seated on edge in the groove.
6. General clean up and removal of any masking.

Saw Kerf is cut into element.

Filling groove with structural adhesive.

(Installation photos courtesy of Univ of Missouri Rolla)

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Installation (con't.)

Inserting CFRP Tape on edge.

Strengthened installation with clean appearance.

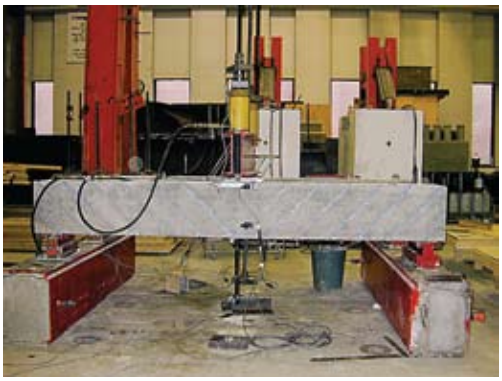
Strengthening

Applications suitable for structural strengthening using Aslan 500 CFRP Tape include:

- Increasing flexural capacity of beams
- Shear Strengthening of beams
- Flexural Strengthening of slabs
- Strengthening of Concrete, Masonry or Timber

During the summer of 2002, the Martin Spring Bridge near Rolla Missouri was strengthened using Aslan 500 CFRP Tape. Load testing of the bridge verified the effectiveness of the NSM methods and bridge posting limits were removed. *(upper right)*

Concrete beam without shear stirrups, designed to fail in shear was strengthened with Aslan 500 as part of undergraduate reinforced concrete design coursework. The resulting failure mode after strengthening was yielding of the longitudinal reinforcing steel. *(right)*



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