

Specification for Build Strip®

Structural Engineers, intend the specification information below for use or other specifies in defining the criteria needed to specify carbon fiber reinforcement systems.

Composite Strengthening & Seismic Retrofit System Carbon Fiber + Epoxy Resin with Die Pultrusion and Heating Equipment formed as Strip Laminates/Plates / Other Profiles

1. PART 1: General

1.01 Work Including

- A. Existing concrete or steel surfaces shall be repaired and reinforced with dry, fiber cure sheet.
- B. The bid is deemed to include furnishings of materials, labor and equipment and all items necessary for repair and reinforcing of the concrete or steel as specified on contract drawings and specifications, complete.
- C. Drawings and the general provisions of the contract, including general conditions and general requirements are hereby made a part of this section.
- D. Cooperate and coordinate with all other trades in executing the work described in the contract.
- E. Inspect the structural members specified to be reinforced with Carbon Fiber Reinforced Plastic (**Build Strip**) on the contract drawings to check the location and inspect cracks and existing conditions of members.
- F. Design and install **Build Strip** laminates to reinforce (Beams, Slabs, Columns, Walls, Pipes, or other).

1.02 Codes and Reference Standards

- A. Comply with provisions of the following codes, specifications and standards, except as otherwise indicated. Standard specifications of the applicable societies, Manufacturer's associations and agencies shall include the latest issues of the specifications. The Contractor shall have the following references and shall be familiar with the reference contents.
 - 1. State of Art Report on Fiber Reinforced Plastic Reinforcement for Structures (ACI 44OR-96).
 - 2. Building Code Requirements for Structural Concrete (ACI 318-95) and (ACI 318R-95).
 - 3. Pull-Out Test-Relates Pull-Out Resistance of Driven Pins to Concrete Strength (ACI 503R).
 - 4. ICRI Surface Preparation Guidelines for Repair of Deteriorated Concrete Resulting from Reinforcing Steel Oxidation, selection of repair materials and placement of repair materials.
 - 5. SACMA 4-88 Test method for tensile properties of oriental fiber resin composites.
 - 6. Concrete Repair Guide (ACI 546R).
 - 7. Guide to the Use of Waterproofing, Dampproofing, Protective, Decorative Barrier Systems for Concrete (ACI 515.R-85).

1.03 Quality Control and Quality Assurance

A. Manufacturer/Contractor Qualifications

Materials Manufacturer/Supplier Company must be specialized in the manufacturing of the products specified in this section.

Materials Manufacturer/Supplier Company must have been in business for a minimum of **Five 5 years**, with a program of training and technically supporting a nationally organized Contractor Training Program.

Contractor shall be a trained Contractor of the Manufacturer/Supplier of the specified product, who has completed a program of instruction in the use of the specified material.

B. Quality Control

The Contractor shall conduct a quality control program that includes, but is not limited to the following:

1. Inspection of all materials to assure conformity with contract requirements, and that all materials are new and undamaged.
2. Inspection of all surface preparation prior to **Build Strip** laminates application.
3. Inspection of work in progress to assure work is being done in accordance with established procedures and established Manufacturer's instructions, specific Engineer Instructions, if given, or recommended practices listed in the references of Section 1.02.
4. Inspection of all work completed including sounding all repairs to check for debonding and correction of all defective work.

C. Quality Assurance

1. Attend pre-installation conference to be held with a representative of the Owner, Engineer, the Contractor's Field Supervisor, and other trades involved to discuss the conduct of the work of this Section.
2. In-situ load testing of concrete structural member prior to and after installation of **Build Strip** laminates plate as required by these specifications. Quantity and location of member (s) to be tested shall be determined by Engineer of Record prior to proposal.

1.04 Submittals

- A. Contractor's Qualifications
- B. Manufacturer's product data indicating product standards, physical and chemical characteristics, technical specifications, limitations, installation instructions, maintenance instructions and general recommendations regarding each material.
- C. Test results on the properties of the epoxy adhesive and the carbon fiber **Build Strip** laminates cured plate systems to be used on the project.
- D. Provide a record of performance of strengthening projects with **Build Strip** laminates (in Asia Pacific, Japan, Europe & North America).
- E. Provide Field Supervisor specifically trained in the installation of **Build Strip** laminates.
- F. Samples of all materials to be used, each properly labeled as specified in Section 2.01.

- G. Manufacturer's MSDS for all materials to be used.
- H. Certifications (in time to prevent delay in the work) by the Producers of the materials that all materials supplied comply with all the requirements and standards of the appropriate ASTM and other agencies.
- I. Submit to the Owner's representative two copies of the strengthening layout details prepared by the Contractor's and/or Owner's professional Engineer using the **Build Strip** laminates to be used on the job.
- J. Submit design drawings by a professional Engineer, including the necessary information listed above in a timely manner to obtain a building permit for the work.
- K. Adhesion testing process for 3.07-D.
- L. Load testing program (process, loads, and shoring) as required.

1.05 Structural Design

- A. Design the repair with **Build Strip** laminates according to the design guides for the **Build Strip** laminates and instructions supplied by the manufacturer.
- B. Structural drawings of the existing structure included in the contract drawings.

1.06 General Procedures

- A. Work only in areas permitted by the Owner approved schedule.
- B. Remove all tools, buckets and materials from work areas and store neatly at an approved location daily at the end of work.
- C. Protect the building and its contents from all risks related to the work in this Section. Schedule and execute all work without exposing adjacent building areas to water, dust, debris or materials used by the Contractor. Protect adjacent areas from damage and stains with appropriate barriers and masking. Repair all damage as a result of the work to its condition at the start of work, or if such cannot be determined, to its original condition.
- D. Protect the work from damage such as impact, marring of the surfaces and other damage.
- E. Compliance with OSHA and all other safety laws and regulations is the exclusive responsibility of the Contractor, his Subcontractors, Suppliers, Consultants and Servants.

1.07 Technical Support

- A. The contractor shall provide the services of a trained Field Supervisor at the work site at all times to instruct the work crew in the **Build Strip** laminates application procedures.
 - 1. The Field Supervisor must be fully qualified to perform the work.
 - 2. The Contractor shall be completely responsible for the expense of the services of Manufacturer's Field Representative if needed at the work site and the contract price shall include full compensation for all costs in connection therewith.

2. PART 2: Products**2.01 Product Delivery, Storage and Handling**

- A. Deliver materials clearly marked with legible and intact labels with Manufacturer's name and brand name, product identification and batch number.
- B. The products shall be in original, unopened containers (except carbon fiber material).
- C. Store materials in areas where temperatures conform to Manufacturer's recommendations and instructions.

2.02 Acceptable Manufacturer/Suppliers

- A. The following vendors shall be used:
- B. Select the **Build Strip®** at below

Type of Products Available & Primer with Adhesive Consumption

Type of Products	Model Grade CFRP	Thickness mm	Width Mm	Roll Length Meter	Primer Require kg per linear meter	Adhesive Require kg per linear meter
Build Strip	HS, HM & UHM	1.2	50	250	0.010	0.34
Build Strip	HS, HM & UHM	1.2	60	250	0.012	0.41
Build Strip	HS, HM & UHM	1.2	80	250	0.016	0.54
Build Strip	HS, HM & UHM	1.2	90	250	0.018	0.62
Build Strip	HS, HM & UHM	1.2	100	250	0.020	0.68
Build Strip	HS, HM & UHM	1.2	120	250	0.024	0.82
Build Strip	HS, HM & UHM	1.2	150	250	0.030	1.02
Build Strip	HS, HM & UHM	1.4	50	200	0.010	0.34
Build Strip	HS, HM & UHM	1.4	60	200	0.012	0.41
Build Strip	HS, HM & UHM	1.4	80	200	0.016	0.54
Build Strip	HS, HM & UHM	1.4	100	200	0.020	0.62
Build Strip	HS, HM & UHM	1.4	120	200	0.024	0.82
Build Strip	HS, HM & UHM	1.4	150	200	0.030	1.02

Build Strip® Mechanical Properties of Specification

Type of Products	Tensile Modulus Gpa	Tensile Strength Mpa	Flexural Modulus Gpa	Flexural Strength Mpa	I L S S Mpa	Density g/cm ³	Elongation at Break
Build Strip HS	165	3000	157	1670	98	1.60	1.9%
Build Strip HM	210	2400	185	1550	94	1.62	1.9%
Build Strip UHM	300	1300	201	1470	90.5	1.62	2.1%

Pultrusion of Carbon Fiber Reinforcement Systems supplied by:

**LaMaCo System Sdn Bhd**

407, Jalan Perusahaan 6, Taman Bandar Baru Mergong,
05150 Alor Setar, Kedah. Malaysia

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Epoxy Adhesive: an approved epoxy system for application of **Build Strip®** Composite System. The system shall include:

- a. Primer
- b. Putty/Filler
- c. Adhesive
- d. Topcoat
- e. Fire Retardant Resin Coat

Substitutions: No substitutions allowed, except as requested by the Manufacturer/Supplier of the product and approved by the Engineer of Record.

Epoxy Adhesive Properties of Specification

Appearance	Component A: 1 part by weight	Component B: 1 parts by weight
Shear Strength	15 N/mm ²	
Peel Strength (Cleavage)	4 N/mm ²	
Tensile Strength	at 35 °C	30 N/mm ²
Tensile Modulus	2 Gpa	
Elongation at Break	4.4 %	
Dielectric Constant	5.6 at 1 kHz (Note: 500v at 35 °C)	
Colour (visual)	Neutral Paste	
Specific Gravity	1.4	
Sag Flow	at 35 °C	0.05 mm to 6.00 mm thick
Shrinkage	0.04%	
Glass Transition Point	> 67 °C	
Coefficient of Expansion	9 x 10 ⁻⁶ per °C at 10°C to 40°C	
Open Time	at 35 °C	> 30 minutes
Pot Life	at 35 °C	> 30 to 40 minutes
Shelf Life / Storage	36 months in original packaging & stored at 5°C to 25°C	

3. PART 3: Execution

3.01 General Preparation for Application

The contract drawings show locations of **Build Strip** laminates

A. Ambient Temperature

Conditions of **Build Strip** laminates process application must be examined carefully during the winter season and/or cold zones. DO NOT APPLY **Build Strip** LAMINATES PLATE WHEN AMBIENT TEMPERATURES ARE LOWER THAN 40 DEGREES °F (5 degrees °C). Auxiliary heat may be applied to raised surface and air temperature to a suitable range. Utilize "clean" heat source (electric, propane) so as not to contaminate bond surfaces by the carbonation of the substrate.

B. Condensation

Presence of moisture may inhibit adhesion of primer and/or adhesive resin. DO NOT APPLY **Build Strip** LAMINATES PLATE WHEN RAINFALL OR CONDENSATION IS ANTICIPATED.

C. Concrete Surface Defects and Corners

UNEVEN CONCRETE SURFACE IRREGULARITIES (OFF SETS) MUST BE GROUND AND SMOOTHED TO LESS THAN 0.04 in. (1 mm). WHEN **Build Strip** LAMIONATES PLATE IS TO RUN PERPENDICULAR TO CORNERS, CONCRETE CORNERS MUST BE ROUNDED TO A RADIUS OF AT LEAST 0.8 in. (22 mm). INTERNAL CORNERS MUST BE SMOOTHED. NO DETAILING IS REQUIRED IF SHEET IS RUN PARALLEL TO CORNERS.

D. Handling of Primer and Adhesive Resin

Refer to Manufacturer's specifications. DO NOT DILUTE PRIMER AND ADHESIVE RESIN WITH ANY SOLVENT. After the resin has been mixed with hardener, the mixed resin batch must be used within its batch-life. The mixed batch resin must not be used after expiration of its batch-life because increased adhesive resin viscosity will prevent proper impregnation of **Build Strip** laminates.

E. Handling of **Build Strip Laminates Plate**

Build Strip Laminates Plate must not be handled roughly. **Build Strip** Laminates Plate must be stored either by being rolled to a radius greater than 12 in. (300 mm) or being dry stacked after cutting. When multiple lengths of **Build Strip** Laminates Plate are adhered to a concrete or steel surface, a 4 in. (100 mm) OVERLAPPING LENGTH MUST BE APPLIED IN LONGITUDINAL (FIBER) DIRECTION. No overlapping is required in the lateral direction (unidirectional sheet only).

3.02 Surface Preparation

- A. All substrates must be clean, sound and free of surface moisture and frost. Remove dust, laitance, grease, curing compounds, waxes, impregnations, foreign particles and other bond inhibiting materials from the surface by blast cleaning or equivalent mechanical means. Any concrete surface including any exposed steel reinforcement or steel surface should be cleaned and prepared thoroughly by abrasive cleaning. Any spalled concrete areas should be patched prior to installation of **Build Strip** laminates.

Any deteriorated concrete or corroded reinforcing steel must be repaired as per ICRI Specifications. Do not cover corroded reinforcing steel with **Build Strip**.

- B. Existing uneven surfaces must be filled with either the epoxy putty or a repair mortar or must be ground flat. If required, the strength of a concrete repair area can be verified after preparation by random pull-off testing. Minimum tensile strength required is **300 psi (2.10 MPa)**.
- C. Prior to initiating surface preparation procedures, the Contractor shall first prepare a representative sample area. The sample area shall be prepared in accordance with the requirements of the Specification, and shall be used as a reference standard depicting a satisfactorily prepared surface.
- D. Where applicable for concrete members, Contractor shall install a sample area (2 ft² or 0.2 m²) of **Build Strip** laminates for purposes of in-situ bond testing to verify bond.
- E. Maintain control of concrete chips, steel particles, dust and debris in each area of work. Clean up and remove such material at the completion of each day of blasting.

3.03 Application Steps

- A. The deteriorated surface layer of the base concrete or steel (weathered layer, laitance, surface lubricants, broken mortar pieces, paint coatings, staining, rust, etc.) must be removed and the surface ground using a grinder or abrasive blasting.

Dusting from surface grinding must be removed using an air blower or other suitable means. If the dust has been removed by means of water washing, the surface must be thoroughly dried.

- B. Restoration of Concrete Cross Section

Defects in the concrete (such as broken pieces, voids, honeycomb, corrosion, etc.) Must be chipped off and removed. If reinforcing bar has been exposed and corrosion exists, it must be repaired before the concrete restoration commences. The repair material shall be selected as per ICRI "Guide to Selecting Repair Material", and project requirements.

Epoxy resin or similar material must be injected into concrete cracks greater than 0.010 in. (0.25 mm) wide.

If water leaks through cracks or concrete joints are significant, water protection and a water conveyance or run-off must be provided prior to concrete surface restoration.

3.04 Mixing Epoxy Resin Adhesive (Non Sagging up to 6mm thickness)

- A. Epoxy based adhesive material used in the composite system may develop higher viscosity and/or slow curing and insufficient curing at low ambient temperature. The ambient temperature of the epoxy components shall be between 50 and 100 degrees F° (10 to 38 degrees °C) at the time of mixing. Presence of moisture may inhibit adhesion of the system to the concrete or steel substrate. Provide necessary weather protection to protect surfaces from rain or cold.
- B. Premix each component of the primer according to Manufacturer's recommendation. Use the appropriate mixing tools, at proper speed to achieve the proper mix. Take care to scrape the sides of the pail during mixing.
- C. Components, which have exceeded their shelf life, shall not be used.
- D. Mix only that quantity of epoxy adhesive, which can be used within its pot life.

3.05 Applications

A. No primer coat should be applied if the ambient temperature is lower than 40 degrees F° (5 degrees °C), or if rainfall or condensation is anticipated.

1. Primer must be thoroughly mixed with hardener at the specified ratio in the mixing pot until it is uniformly mixed (about 2 minutes). Agitation shall be by means of electric hand mixer. Volume of primer prepared at one time must be such that it can be applied within its batch life. A mixed primer batch that has exceeded its batch life must not be used. (The batch life may vary subject to ambient temperature or volume of the mixed primer batch and care must be taken accordingly.)
2. Prime the concrete or steel surface with the penetrating primer prior to application of any subsequent coatings using brush or roller. Alternatively, the primer may be spray applied with airless spray equipment, followed immediately by thorough back rolling to work the primer into the concrete surface. The primer shall be applied uniformly in sufficient quantity to fully penetrate the concrete or cover the steel and produce a nonporous film on the surface not to exceed two (2) dry mils (50 micrometers) in thickness after application. Volume to be applied may vary depending on direction and roughness of the concrete or steel surface.
3. Surface irregularities caused by primer coating must be ground and removed using disc sander, etc. If any minor protrusions on the concrete or steel surface still remain, such surface defects may be corrected again using epoxy resin base putty/filler as needed.
4. Apply base putty/filler to primed surfaces to fill all substrate voids and irregularities. (See 3.01-C.)

B. Adhesion of Build Strip Laminates Plate

Build Strip Laminates Plate shall not be applied whenever ambient temperature is lower than 40 degrees F° (5 degrees C°), or whenever rainfall or condensation is anticipated.

1. **Build Strip** laminates must be cut beforehand into prescribed sizes using scissors and/or cutter. The size of **Build Strip** laminates to be cut is preferable less than 30 ft. (9.00 m) in length, but may be longer if access allows.
2. When the primer coat has been left unattended for more than one week after the application, the surface of the primer coat must be roughened using sandpaper. Do not solvent wipe.
3. Apply Epoxy Adhesive Resin to primed surface at rate applied 0.25 kg/meter linear to 1.5 kg/meter linear, paste adhesive is high viscosity, and is non sagging paste adhesive materials that is applied using Spatula Tools to level on concrete surfaces.
4. **Build Strip** laminates is placed onto the concrete or steel surface where the wet Epoxy Adhesive Resin has been applied. The surface of adhered **Build Strip** laminates must be squeezed in the collect direction(s) using a roller in order to press adhesive resin until is forced out from both sides of **Build Strip** laminates.

Minimize the elapsed time between mixing and application of the Epoxy Adhesive to ensure the material is applied to the sheet at least 15 until 120 minutes prior to any thickening or gelling.

5. The final coat of epoxy adhesive resin (Fire Retardant Adhesive Resin) must then be applied onto the surface of the **Build Strip** laminates.

6. In the case of outdoor application, the work must be protected from rain, sand, dust, etc. by using protective sheeting and other barriers. Curing of adhered **Build Strip** laminates must be for exceed less than 6 hours (dry to touch) prior to application of topcoat.

3.06 Repair of Defective Work

- A. Repair of all the defective work after the minimum cure time for the **Build Strip** laminates. Comply with material and procedural requirements defined in this specification. Repair all defects in a manner that will restore the system to the designed level of quality. The Owner's representative shall approve repair procedures for conditions that are not specifically addressed in this specification. All repairs and touch up shall be made to the satisfaction of the Owner's representative.

3.07 Testing of the Installed Build Strip Laminates

- A. Test all the repaired areas to check for voids, bubbles and delaminating. Repair all voids, bubbles and delaminating by approved methods per manufacturer's direction.
- B. Conduct direct pull-off test (concrete member only) to verify the tensile bond between the **Build Strip** laminates and the existing concrete substrate. Inspect the failure surface of the core specimen. Failure at the bond line at tensile stress below **300 psi (2.10 Mpa)** is unacceptable.
- C. Perform a minimum of one pull-off test (concrete member only)
Per _____ / ft² (_____ / m²) strengthened with the **Build Strip** laminate system. The test is to be completed prior to the application of topcoat finishes on the **Build Strip** laminates.
- D. Repair the test areas of the composite system to the satisfaction of the Owner's representative.

3.08 Quality Control and Inspection

- A. In Process Control

The Field Supervisor shall observe all aspects of onsite material preparation and application, including surface preparation, resin component mixing, application of primer, resin and **Build Strip** Laminates, curing of composite, and the application of protective coating.

- B. Inspection for Void/Delaminating

After allowing at least 24 hours for initial resin cure to occur, perform a visual and acoustic tap test inspection of the layered surface. Large delaminating shall be marked for repair. For small delaminating, which are typically less than 2 in.² (1300 mm²) do not require corrective action.

- C. Adhesion Testing

Adhesion Test: The Contractor will conduct adhesion testing of the fully cured **Build Strip** Laminates concrete assembly. (See 3.07.)

- D. Load Testing

If required by the Engineer, a representative area(s) shall be in-situ load tested before and after application of **Build Strip** laminates to verify results. The insitu test shall be designed by the Engineer of Record and carried out by a designated third party at owner's expense.

E. Report

The Field Supervisor shall keep a copy of daily log report for inspection of the Engineer of Record.

Bill of Quantity

Item	Description	Unit	Rate / US\$
BQ-1	Load Test If required by the Engineer, a representative area(s) shall be in-situ load tested before and after application of CFRP Sheet to verify results. The insitu test shall be designed by the Engineer of Record and carried out by a designated third party at owner's expense.		
BQ-2	Professional Structural Engineer To appointing professional structural engineer, with design full specification of Repair, Strengthening & Seismic Retrofit.		
BQ-3	Structures Surface Preparation To prepare the structures smooth surfacing, examples: Patching Cementitious Mortar. Injecting of Load Bearing or High Strength Epoxy Resin into cracks line.		
BQ-4	Applied Carbon Fiber (Strip Laminates Plate) Applied Putty Applied Primer Applied 1 st layer of Adhesive Resin Laying Carbon Fiber Strip Laminates/Plate <i>Stated Thickness & Type of Strip Laminates</i> Final Finish Coatings shall Normal Resin Coat or <i>Fire Retardant Coat - Fire Rating at least 1/hour</i> The above-mentioned system to be accordingly to instruction of manufacturing details specification.		
BQ-5	Pull-Out Test Pull-Out Test-Relates Pull-Out Resistance of Driven Pins to Concrete Strength (ACI503R).		
BQ-6	Quality Assurance In-situ load testing of concrete structural member prior to and after installation of CFRP sheets as required by these specifications. Quantity and location of member (s) to be tested shall be determined by Engineer of Record prior to proposal.		

Pultrusion of Carbon Fiber Reinforcement Systems supplied by:



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