

**Master Builders Solutions
Construction Chemicals LLC**

**Application Guide
For
MasterBrace
Strengthening Systems**

MasterBrace Laminate

IMPORTANT: READ THIS FIRST

Master Builders Solutions Construction Chemicals LLC do not warrant the performance of this product unless the instructions of this document and other related **Master Builders Solutions Construction Chemicals LLC** documents are adhered to in all respects.

1. GENERAL:

This application guide applies specifically deals with the pre-formed (pultruded), **MasterBrace LAM** (Laminate strip). This application guide shall be read in conjunction with all project specifications (including drawings), by others, and the current technical data sheets (TDS) and material safety data sheets (MSDS).

Repairs: Any repairs to the substrate and surface preparation required, shall be done to the satisfaction of the specifying consulting engineer and Master Builders Solutions.

Application Requirements: All work shall be carried out by adequately trained and skilled sub-contractors, under appropriate supervision.

Safety: Always ensure the appropriate use of adequate PPE (gloves, goggles, long sleeves etc.) and comply with all other safety related requirements when applying **MasterBrace** materials.

Quality Systems: The applicator shall operate under a fully compliant quality system, to ensure the on-site quality of applied material. The applicator shall keep fully documented work records for all works undertaken.

Quality Control: If after application and/or testing, any applied material is deemed as unsatisfactory by the specifying consulting engineer and/or Master Builders Solutions, it may need to be rectified at the applicator's cost.

Weather: No product application work is to be carried out in temperatures below 5°C or above 45°C, unless special precautions are taken.

Part A – Preparation

A1. Concrete substrate:

A load-bearing substrate is a pre-requisite for the reinforcement with all **MasterBrace LAM** applications. The concrete substrate should be at least 28 days old. A tensile bond strength of the substrate of **>1.5 MPa** is required. Testing of the substrate shall be performed as required utilizing the testing procedure indicated in Appendix A, "General Description of Tensile Pull-Off Test" document. This should be tested prior to work proceeding and to verify the contractor's chosen preparation procedures.

All cement laitance must be removed prior to application. The surface layer of the concrete shall be removed to expose small particles of sound aggregate such that the minimum roughness or surface profile to be achieved is CSP 3, as per ICRI (International Concrete Repair Institute) Technical Guideline No. 310.2R-2013. The optimum mean surface roughness or profile is 0.5 – 1.0 mm and must expose soundly bonded aggregate with a surface similar to 60-grit sandpaper. The surface shall not be roughened excessively, or in a manner that will create unnecessary damage to the substrate concrete. Ideal surface preparation methods are grit blasting, shot-peening or grinding. Any additional water must be avoided. Dirt, oil, grease and other contaminants must be removed. Immediately prior to the application of the **MasterBrace LAM** strengthening system including levelling mortar and or adhesive, the surface must be cleaned with a brush or a vacuum cleaner to remove all loose particles and dust.

Cracks in the substrate concrete need to be assessed and treated depending on their location and movement characteristics. Cracks parallel to the laminate, generally need no special treatment. All cracks crossing the laminate shall be epoxy injected using suitable high pressure injection equipment and packers etc. and **MasterInject 1315**.

Immediately prior to application, remove all loose dust particles and carry out a visual inspection of the concrete surface.

Measure the moisture content of the concrete substrate. The moisture content of the concrete must be below 4% when checked with a surface type electronic moisture meter.

A2. Concrete Flatness:

Generally, the **MasterBrace LAM** shall not be positioned on surfaces that, under load, reverse the curvature that the **LAM** originally forms on application. That is, for a **MasterBrace LAM** on the underside of a typical slab or beam, an upward substrate curvature (or hog) is generally unacceptable. A flat or very slight downward substrate curvature (or sag) is acceptable.

The flatness of the concrete substrate surface must be checked by means of a metal straight edge. The surface flatness shall not exceed 5 mm within a substrate length of 2 metres. Furthermore, the general flatness shall not exceed 1 mm in 300 mm for any length of **MasterBrace LAM**.

A3. Levelling of the Substrate:

Where required, any voids must be levelled, by either grinding the surface flat, or building it up, with a levelling mortar. Local grinding of high points and removal of formwork edges etc. is mandatory to achieve the required profile.

Generally, voids are levelled with an epoxy based levelling mortar (**MasterBrace ADH 2200**) at least 1 day prior to the application of the laminate.

In extreme situations, the levelling mortar can be bulked out with **MasterTop SR 2** filler 1 to 1 by volume to aid in deep fills, greater than 20 mm. The levelling mortar shall generally be left with a smooth yet open textured, level surface. If the **MasterBrace LAM** is applied in excess of 24 hours after levelling, prepare the levelling surface by abrading with a belt sander or similar and wiping the surface with a solvent soaked rag (Xylene / MEK).

Alternatively, level voids by use of a cementitious based mortar (**MasterEmaco S488 PM**). This must be placed at a thickness of not less than 10 mm and cured to a moisture content of <4% prior to application of the **MasterBrace LAM** material.

A bond strength of >1.5 MPa for the repair system used must be achieved.

A4. Environmental conditions:

Do not apply any of the **MasterBrace LAM** system components when rainfall or condensation is anticipated.

In general, for application of any of the **MasterBrace LAM** systems, the ambient temperature must be at least +5°C and should not exceed 45°C. The temperature of the substrate concrete must be higher than +8°C.

Determination of dew point, air and substrate temperatures and of relative humidity of air, immediately prior to the application is required, if the substrate is exposed to the weather or is in an external environment. If the dew-point temperature differs by less than 3°C from the substrate temperature, the substrate must be warmed up, or the relative humidity of the air must be reduced. Application may proceed if the "concrete surface" temperature is > Dew point + 3° C".

A5. Set-out

Careful set-out and masking of the edges 5 mm beyond the width of the **MasterBrace LAM material**, will aid in producing a neat appearance to the finished work.

Part B – General Application

B1. Working with epoxy resins

Do not dilute any epoxy resins used with the **MasterBrace FIB** systems with solvent.

After the base resin has been mixed with hardener, the mixed resin batch must be used within its pot-life. This sometimes referred to as open-time or batch-life. The mixed batch of resin must not be used after expiration of its pot-life, as the adhesion may be affected.

Part C - MasterBrace Laminate

C1. Handling

Handle with care: **MasterBrace LAM** carbon plates can be fragile if improperly handled. Manual handling should always be with protective gloves to prevent harm from carbon splinters / shards.

Delivery: **MasterBrace LAM** plates are normally delivered to site in two ways. Both packaging methods, may be handled with a fork-lift on site.

- In rolls that are packaged into cardboard boxes, loaded on pallets.



- In pre-cut lengths, packaged in wooden crates.



Storage:

MasterBrace LAM plates require protection against heat, sun and weather. They must be stored on a solid, flat and dry surface, inside a ventilated shelter. If stored in the open, protect with opaque waterproof covers. Rolls must be stored only in the horizontal position.

Minimum Roll diameter: **MasterBrace LAM** rolls are delivered with a specific roll diameter (800 mm in most cases). This specific diameter is the minimum diameter. In case of re-rolling, the minimum diameter must never be reduced.

Unpacking of Rolls:

All **MasterBrace LAM** that is delivered in rolls, are provided with plastic straps. Unrolling should be completed by at least 2 persons. While one maintains the roll in position, the second cuts the plastic straps one by one. The beginning and end on unrolling are the 2 critical phases of unpacking a roll. Alternatively, a simple roller frame may be used to help hold the **MasterBrace LAM** in position (refer photos below).

**Cutting:**

MasterBrace LAM plates should be cut with a diamond tipped cutting disc on a small angle grinder. Protection against dust is required. Cutting with a metallic fine toothed hand saw are acceptable alternative solutions.

Drilling: Do not drill **MasterBrace LAM** plates, otherwise the mechanical properties will be altered.

Application of MasterBrace LAM (summary)

C1. Surface Preparation.



Initial surface preparation of the concrete substrate by grinding or grit blasting (where permitted).

C2. Preparation of MasterBrace LAM



Thoroughly clean the surfaces of the laminate using a white rag and a solvent-based cleaner (Xylene / MEK), in order to remove carbon dust and other contaminants. Cleaning must be repeated until the white rag remains free of black carbon dust and the surface is clean of all contaminants.

When cutting the **MasterBrace LAM** to length, wrap the laminate with masking tape prior to cutting with an angle grinder or similar. Mount laminate securely during this operation to prevent longitudinal splitting.

C3. Mixing of MasterBrace ADH 4000 Epoxy Adhesive



Mix the **MasterBrace ADH 4000** epoxy adhesive PTA and PTB together into a streak-free colour using a suitable slow speed mixer and mixing paddle. Ensure the sides of the tin are scrapped down and material re-mixed thoroughly.

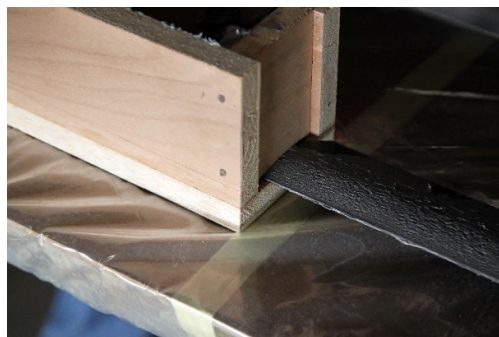
C4. Application of MasterBrace 4000 adhesive



The instructions of the technical data sheet must be followed. In particular, mixing of full kits, correctly proportioned and by a mixing drill with an appropriate paddle, for at least 3 minutes, is required.

MasterBrace ADH 4000 adhesive is generally applied onto both the concrete surface (thin even layer – do NOT use a notched trowel) and the back of the laminate, to minimise the air voids in the final adhesive layer.

The homogeneously mixed epoxy adhesive (**MasterBrace ADH 4000**) is applied to the concrete surface by means of a steel trowel / scrapper. In the masked - off application area of the **MasterBrace LAM**, the concrete surface should be completely covered with the adhesive to a nominal thickness of between 1-2 mm.



Using an "application box" as shown, apply a convex layer of **MasterBrace ADH 4000** onto the pre-cleaned face of the **MasterBrace LAM**. The "gate" of the applicator box should be profiled to create a 2mm thick (in the centre) convex layer of **MasterBrace ADH 4000** tapering down to less than 1mm at the edges.



Ensure that the entire surface of the **MasterBrace LAM** is covered with the **MasterBrace ADH 4000 adhesive**. Do NOT leave any bare spots on the surface of the LAM as this will create air voids within the **LAM** application once cured.

C5. Application of the MasterBrace LAM



Lightly press the **MasterBrace LAM** strip with gloved fingers onto the prepared application area. The **MasterBrace LAM** strip is then pressed on with a hard rubber roller until the fresh adhesive exudes from both sides of the laminate. Roll the laminate first in the centre of the strip and then roll each edge. This guarantees that no significant voids exist between the laminate and the substrate surface. The excess adhesive can be removed by means of a spatula. The mean layer thickness of the final adhesive should be 2mm (min. 1mm – max. 3mm).



Remove the masking tape once the **LAM** is correctly positioned, excess epoxy adhesive has been extruded and before it hardens.

If desired, adhesive residues on the laminate surface can be removed with Xylene / MEK solvent or soapy water before hardening. Additional **MasterBrace LAM** strips can be applied in parallel at a minimum distance of 5mm.

Due to the very high thixotropic nature of the **MasterBrace ADH 4000**, no support devices are normally required. In certain cases however, some form of temporary fixing may be required. Examples of this include situations where the weight is excessive (e.g. wide and thick laminates >1.4 mm) or where the laminate wants to straighten

(e.g. where the substrate changes direction and the laminate has a slight bend in it).

During the application and until hardening of the adhesive (normally after 1-2 days), any vibration that could affect the application area must be avoided.

In the case of outdoor applications, the work must be protected from rain, sand, dust, etc. by using protective sheeting and other barriers until fully cured. The curing rate of the adhered **MasterBrace LAM** is temperature dependent.

If there is to be a fire protection / plaster skin required over the **MasterBrace LAM** installation, provide a sand-seeding broadcast onto a still-wet, application of **MasterBrace P 3500** applied to the **MasterBrace LAM** after 24 hours initial curing, and after testing for any delamination etc.

Part D – Other Considerations

D1. Quality control

After allowing at least 24 hours for initial resin cure to occur, perform a visual and acoustic tap test inspection of the layered surface. Test all the areas where **MasterBrace LAM** is applied to check for voids, and delamination. Repair all voids, bubbles and delamination by approved methods as per the requirements of the specification and to Master Builders Solutions satisfaction.

In addition, the evenness of the **MasterBrace LAM** surface shall be checked. Deviations within a test length of 300mm may not exceed 1mm. If the test length measures over 2m, the maximum deviation is 5mm.

Direct pull-off tests shall be conducted to verify the tensile bond between the **MasterBrace LAM** material and the concrete substrate. For further information, refer to Appendix A, "General Description of Tensile Pull-Off Test". These should be conducted on approved "test areas" and not sections of the actual work.

Unless otherwise directed by the project specification, perform a minimum of one pull-off test per 100 m of laminate length (or a minimum of two per project), to surfaces strengthened with the **MasterBrace FIB** materials. The test is to be completed prior to the application of any additional fire protection finishes etc. on the **MasterBrace FIB** materials.

- a.) An average of 1.5 MPa minimum shall be obtained from these adhesion tests. Inspect the failure surface of the core specimen to ensure that failure is in the concrete substrate. Failure at the bond line at tensile stress below 1.35 MPa is not acceptable.

D2. Repair Techniques

The installation of Carbon Fibre Laminates (**MasterBrace LAM**) does NOT lend itself to "repair" as these laminates cannot be cut under any circumstances without losing their structural benefit.

Sounding of the cured system should take place and very small voids not in excess of 5% of the laminates width "may" be acceptable. Voids located within the very critical anchoring areas (ends) should be avoided at all costs.

There is no way of "repairing" voids within the boundaries of the laminate and if considered

to be excessive, would require the removal and replacement of the tested element.

D3. Heat Protection Measures

Since 2-component epoxy resins can only withstand temperatures of up to 70°C approximately, special attention may be required for heat protection measures (eg under fire exposure).

D4. Cold Weather Application / Accelerated Curing

For applications in cold weather or where accelerated curing is required due to time constraints, a number of methods are recommended.

- a) Pre-heat the **MasterBrace ADH 4000** adhesive at 25° C for 30 mins prior to mixing.
- b) After one hour of placement, maintain an ambient air temperature in the vicinity of the laminate not exceeding 50° C, for an additional hour (minimum). This is usually done by enclosing the structure and heating as required.
- c) Maintain heat in the laminate and adhesive directly, by covering with heating blankets or similar.

D5. Hot Weather Application

For applications in warm weather or where retarded curing is desirable, a number of methods are recommended.

Pre-cool the adhesive in an air-conditioned or chilled water bath environment at 15- 20°C for at least 8 hours prior to mixing.

Work during the cooler parts of the day / night and shade materials and application surfaces wherever possible.

Minimize heat build-up in the epoxy materials by mixing smaller portions and / or spreading mixed material out into smaller volumes prior to use. Discard any material that has changed consistency since first mixing.

This guideline will not cover every project requirement. Therefore, a project specific method statement may be required for heat curing, application method, surface preparation, timing of application and hand over periods to mention a few.

Appendix A - General Description of Tensile Adhesion Test

The following is a description of a field test for concrete surface soundness and overlay bond (ex-ACI 503R, Appendix A: Manual of Concrete Practice, Part 5 and Concrete Society TR 57), to serve as the in-situ QA/QC test of the **MasterBrace** Composite Strengthening System.

The tests should be carried out on test panels and NOT the actual strengthening areas (unless specifically instructed) strengthened with the composite **MasterBrace FIB** system. Although there are variations in the equipment for carrying out pull-off tests, the general procedure can be summarized as follows:

After the composite strengthening system has hardened, core drill through the composite material and down 3 – 6 mm into the concrete substrate by means of an electric drill fitted with a diamond core bit. The core bit should be of such size as to produce a core the same

diameter as the testing dolly, and which will have the appearance of a small island of

composite material. The normal size of the dolly is 50 mm diameter. Ensure that the drilling operation does not cause any detrimental effects on the system by using wet drill techniques to minimise heat exposure, and ensure it is perpendicular to the surface.

Prepare the top of the core surface to be tested. Preparation includes cleaning of the composite material surface, roughening it with sandpaper, and final cleaning of any dust.

Place an aluminium dolly onto the surface of the core with epoxy adhesive (**MasterBrace ADH 2200**). The bottom surface of the dolly should be sandblasted or sufficiently roughened with sandpaper and be cleaned and free from any grease or dust. Mix the epoxy components as per the recommendations on the TDS just prior to use. Apply a small amount of the mixed adhesive to the core surface and to the bonding (properly prepared) face of the dolly by spatula. Place the dolly on the core using light pressure to ensure the adhered faces are in fully contact with each other. Remove the extruded epoxy from the dolly perimeter before it sets.

Allow epoxy adhesive to cure sufficiently (usually 24 hours or as required).

Attach a loading frame (Proceq or similar) to the dolly such that a load can be applied at right angles to the surface. A frame around the test area provides the reaction force to the load. Ensure that the attachment of the loading frame does not induce any lateral sideways force onto the dolly, either prior or during testing.

Zero the machine and increase the load until a specified level is reached or the specimen fails.

At failure, the maximum pull-force is registered and the pull-off tensile strength is calculated by dividing the force by the cross-sectional area of the core. The mode of failure shall be recorded i.e., within the concrete substrate, within the composite material, between substrate and composite material, between composite material and dolly, or any combination of the above.

Pull-off tests shall be carried out on each selected area. The average of the values shall be taken as a pull-off strength result.

Unless otherwise indicated by project specification requirements, most composite strengthening applications require minimum tensile strengths of the substrate of:

1.5 MPa for **MasterBrace LAM** systems.

Appendix B – Application of Hot Mix Asphalt

When applying **MasterBrace LAM** materials and the intention is to overlay with hot-mix asphalt, the following general guidelines need to be addressed. Specific details need to be considered for each particular application, with reference to Master Builders Solutions once all parameters are known.

The temperature of the hot-mix shall be limited whenever possible, to the lowest practical temperature. Generally, temperatures shall not exceed 150°C, at the point of discharge.

The **MasterBrace LAM** materials shall be protected from this temporary temperature rise by

one of two methods:

Turn the laminate strip on edge and insert vertically into saw-cuts, pre-cut into the concrete substrate – Near Surface Mounting (preferred) or

c. Provide a protective mortar layer of minimum thickness 20 mm on top of the laminate, extending no less than 50 mm beyond the laminate edge, as per the following procedures:

- I.) Apply the **MasterBrace LAM** as per normal practices.
- II.) Lightly sand the top of the laminate without damaging the fibres and solvent wipe to remove any dust.
- III.) Apply a thin layer of **MasterEmaco P 102** as a primer for the protective mortar layer.
- IV.) Apply a protective mortar layer of **MasterEmaco S488PM** (or **MasterEmaco S466PM**) to the wet primer, to a minimum thickness of 20 mm.
- V.) Apply hot mix asphalt over entire surface no sooner than 7 days after application of mortar layer.