

MBRACE APPLICATION GUIDELINES

MBrace Laminate

(Carbon Fibre Laminate materials)

Version : May 2009

0. General

This application guide applies to the application of one type of the MBrace Composite Strengthening System, specifically dealing with the pre-formed (pultruded), MBrace Laminate strip (plate) type. Refer to a separate application guide for use of sheet (fabric) type FRP systems. This application guide shall be read in conjunction with all project specifications (including drawings), by others, and the current material technical and material safety data sheets (MSDS).

1. General Conditions of Use – Summary of Conditions

- Handle with care: MBrace Laminate carbon plates can be fragile if improperly handled. Manual handling should always be with protective gloves to prevent harm from carbon splinters.
- Delivery: MBrace Laminate plates are normally delivered to site in two ways.
 - o Both packaging methods, may be handled with a fork-lift on site.
 - o In rolls that are packaged into cardboard boxes, loaded on pallets



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



- Storage: MBrace Laminate 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: MBrace Laminate 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.

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- Unpacking of rolls: All MBrace Laminate that are 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 MBrace Laminate in position (refer photos below).



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- Cutting: MBrace Laminate plates should be cut with diamond coated tools. The cutting speed should be between 20 and 80m/s. Protection against dust is required. A guillotine saw of proper size (refer photo below) as well as a metallic hand saw are acceptable alternative solutions.



- Drilling: Do not drill MBrace Laminate plates, otherwise the mechanical properties will be altered.
- Peel-ply: Most of the MBrace Laminate plates are delivered with 2 peel-plies, which must be removed before bonding.



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- Repairs: Any repairs to the substrate and surface preparation required, shall be done to the satisfaction of the specifying consulting engineer and BASF.
- 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 MBrace 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 BASF, it may need to be rectified at the applicator's cost.
- Weather: No product application work is to be carried out in temperatures below 5⁰C or above 30⁰C, unless special precautions are taken.
- Continuity of Process: All applications shall be done in continuous operations, including first primer coat, through to last layer of laminate, without significant delay.

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Summary of Application steps required for MBrace Laminate System.

Laminate System



1 Apply MBrace Primer onto prepared concrete substrate



2 Level prepared concrete substrate with MBrace Putty / Levelling Mortar (optional)



3 Apply MBrace Laminate Adhesive to substrate



4 Remove Peel-Ply from Laminate. The easiest way to take off the peel-ply is with a cutter/Stanley knife. Start to lift the peel-ply with the knife (start from the corner as it will be the easiest spot) and move the knife across the sheet. Once the peel-ply has started to lift, pull back by hand the required length of the Laminate.



5 Apply MBrace Laminate Adhesive to Laminate



6 Position MBrace Laminate and apply to substrate



7 Roll MBrace Laminate to secure onto substrate and clean up excess



8 Apply MBrace Topcoat (optional)

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1. Concrete substrate

A load-bearing substrate is a pre-requisite for the reinforcement with FRP laminates. All concrete substrate shall be of 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 optimum mean surface roughness or profile is 0.5 – 1.0 mm, and must expose soundly bonded aggregate with a surface presenting similar to 60-grit sandpaper. 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 FRP strengthening system including epoxy primer, 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 (high pressure type, using the SCBP system and resins, such as Concessive 1375/1380).

2. Preparation/Quality control

Remove all loose dust particles and adopt visual control of the concrete surface.

Measure the moisture content of the concrete substrate. The moisture content of the concrete must be below 4% or its relative humidity less than 70% according to AS1884-1995. 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 "concrete temperature $>$ Dew point + 3 deg C".

In general, for application of FRP Laminate, the ambient temperature must be at least 5°C and may not exceed 35°C . The temperature of the substrate concrete must be higher than 8°C .

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3. Testing of flatness

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

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 laminate.

4. Levelling of Substrate

Where required, the voids must be levelled, by either grinding the surface flat, or building it up, with a levelling mortar.

Generally, voids are levelled with an epoxy based levelling mortar (like MBrace Laminate Adhesive) at least 1 day prior to the application of the laminate. Clean and prime the surface with MBrace Primer prior to application of the levelling mortar. Apply the levelling mortar while the primer is still tacky. If the primer is allowed to dry, the surface must be re prepared and primed prior to any work proceeding.

In extreme situations the levelling mortar can be bulked out with F2 filler 1/1 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 laminate is applied in excess of 24 hrs after levelling, prepare the levelling surface by grinding with a belt sander or similar and wiping the surface with a solvent soaked rag (Thinner No 1).

Alternatively, level voids by use of a cementitious based mortar (Emaco Nanocrete R4). This must be placed at a minimum thickness of 10 mm and cured to a moisture content of <4% prior to application of the laminate. Local grinding of high points and removal of formwork edges etc is mandatory to achieve the required profile.

Careful setout of the laminates and masking of the edges 5 mm beyond the width of the laminates, can easily produce an aesthetic result.

5. Priming

Bond strengths of the substrate will be improved by priming prior to the application with MBrace Primer. Apply the levelling mortar while the primer is still tacky. If the primer is allowed to dry, the surface must be re prepared and primed prior to any work proceeding.

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6. Cleaning & Preparation of BASF CF Laminates

The range of MBrace CF Laminates comes supplied either with a peel-ply protection or as a plain laminate.

For peel-ply laminates, simply remove the peel ply using the following procedure and as per Appendix C:

- 1) Take a sharp cutting blade and scrape along the width of the laminate, until the peel ply starts to come loose.
- 2) Working from one corner, lift the peel-ply with the help of the cutter.
- 3) Using the cutter by running the blade under the peel-ply, lift a small section of the ply, across the whole width of the laminate.
- 4) When you can grip the peel-ply, gently remove it along the full length of laminate to reveal the clean laminate ready for adhesion. There is no need to use solvent to clean the laminate, unless it gets contaminated.

For plain laminates, thoroughly clean the non-stamped surface of the laminate using a white rag and a solvent-based cleaner (Thinner No. 1), 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 plain type FRP Laminate to length, wrap the laminate with adhesive tape prior to cutting with an angle grinder or similar. Mount laminate securely during this operation to prevent longitudinal splitting.

7. Mixing of the epoxy adhesive (MBrace Laminate Adhesive)

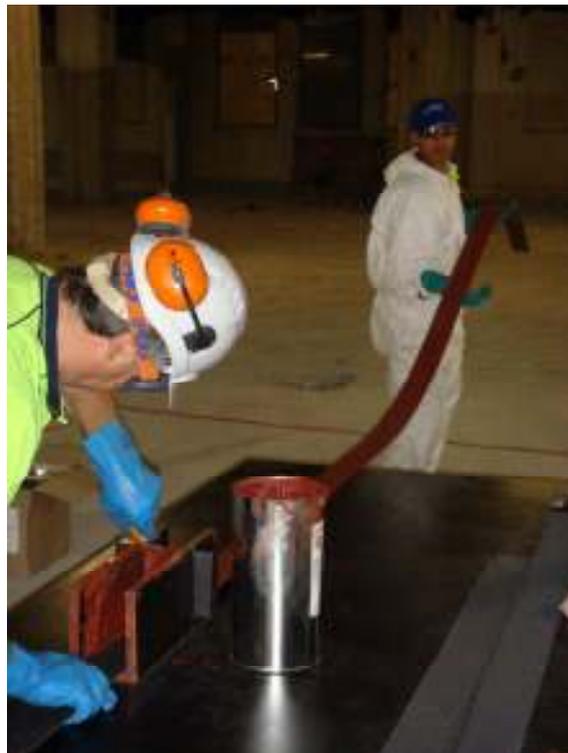
The instructions of the technical data sheet must be followed. In particular, mixing of full kits, correctly proportioned and by a mixing drill with an appropriate paddle, for at least 3 minutes, is required.

8. Application of the adhesive

The homogeneously mixed epoxy adhesive (MBrace Laminate Adhesive) is applied to the concrete by means of a notched steel trowel or similar. In the application area of the laminate, the concrete surface shall be completely covered with adhesive to a nominal thickness of between 1-2 mm.

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The cleaned and fully dried FRP laminate is then coated in a "V" profile with the MBrace Laminate Adhesive by means of a purpose made dispenser box or trowel to give a nominal thickness of 2 mm in the middle of the laminate tapering to 1 mm at the edges.



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9. Application of the FRP Laminate to the concrete

Lightly press the FRP Laminate with the fingers onto the prepared application area. The FRP Laminate 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 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).

If desired, adhesive residues on the laminate surface can be removed with the Thinner No. 1 before hardening. Additional FRP Laminates can be applied in parallel at a minimum distance of 5mm.

Due to the very high thixotropy of the MBrace Laminate Adhesive, 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 (eg wide and thick laminates >1.4 mm) or where the laminate wants to straighten (eg where the substrate changes direction and the laminate has a slight bend in it).

10. Quality control

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.

After hardening of the adhesive, the FRP laminates shall be tested for cavities with a tap test. In addition, the evenness of the laminate 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.

Check for any delamination after hardening of the adhesive by conducting a tap test along the length of each applied laminate.

Conduct direct pull-off test to verify the tensile bond between the FRP laminate and the existing concrete substrate. For further information, refer to Appendix A, "General Description of Tensile Pull-Off Test". Inspect the failure surface of the core specimen. Failure at the bond line at tensile stress below 1.5 MPa is not accepted. Perform a minimum of one pull-off test per 100 m of laminate length (or a minimum of two per project) or as directed by the project specification, surfaces strengthened with the FRP laminate system. The test is to be completed prior to the application of finishes on the laminates.

11. Heat protection measures

Since 2-component adhesives withstand temperatures of up to 80°C approximately, special attention may be required for heat protection measures (eg under fire exposure

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or with application of hot-mix asphalt). For application with hot mix asphalt, refer to Appendix B.

12. 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 adhesive at 25⁰C 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 50⁰C, 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.

13. Hot Weather Application

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

- a) Pre-cool the adhesive in an air-conditioned (or chilled water) environment at 15-20⁰C for at least 8 hrs prior to mixing.
- b) Work during the cooler parts of the day and shade materials and application surfaces wherever possible.
- c) 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.

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Appendix A - General Description of Tensile Pull-Off 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 AS/NZS 1580.408.5:1994), which have been modified to serve as the in-situ QA/QC test of the MBrace Composite Strengthening System.

The tests are carried out on actual structural members strengthened with the composite FRP system. Although there are variations in the equipment for carrying out pull-off tests, the general procedure can be summarized as follows:

1. 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 carbide-tipped or 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.
2. 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.
3. Place an aluminium dolly onto the surface of the core with epoxy adhesive (Concresive 1444 or similar). The bottom surface of the dolly has to be sandblasted or sufficiently roughened with sandpaper, and be cleaned and free from any grease or dust. Mix the epoxy components according to the recommendations 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. In some cases, a disk is bonded to the composite surface prior to core drilling.
4. Allow epoxy adhesive to cure sufficiently (usually 24 hours or as required).
5. Attach a loading frame (Proseq 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.
6. Zero the machine and increase the load until a specified level is reached or the specimen fails.
7. 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.
8. 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.
9. Unless otherwise indicated by project specification requirements, most composite strengthening applications require minimum tensile strengths of the substrate of:
 - a. 1.0 MPa for fibre fabric sheet material systems.
 - b. 1.5 MPa for laminate material systems.

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Appendix B – Application of Hot Mix Ashphalt

When applying FRP Laminate and the intention is to overlay with hot-mix ashphalt, the following general guidelines need to be addressed. Specific details need to be considered for each particular application, with reference to BASF once all parameters are known.

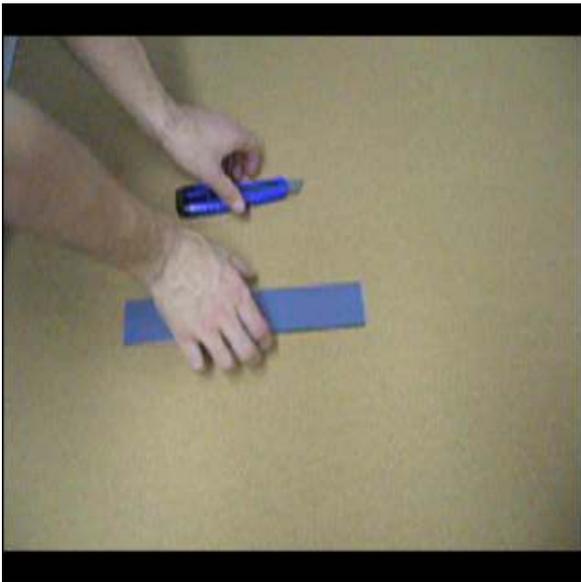
1. The temperature of the hot-mix shall be limited whenever possible, to the lowest practical temperature. Generally, temperatures shall not exceed 150 deg C, at the point of discharge.
2. The FRP Laminate shall be protected from this temporary temperature rise by one of two methods:
 - a. Turn the laminate strip on edge and insert vertically into saw-cuts, pre-cut into the concrete substrate (preferred) or
 - b. 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 FRP Laminate 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 MBrace Laminate Adhesive as a primer for the protective mortar layer.
 - iv.) Apply a protective mortar layer of Emaco T920 (or Emaco Nanocrete R4) to the wet primer, to a minimum thickness of 20 mm.
 - v.) Apply hot mix ashphalt over entire surface no sooner than 7 days after application of mortar layer.

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Appendix C – Procedure for removal of peel-ply

For carbon laminates supplied with a peel-ply, please follow the following removal procedure for successful application.

Equipment needed: Cutter blade, two hands and carbon laminate



Prepare the section to be removed:

1.



2.



3.



==> Aim to loosen edge of peel-ply



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Lift the peel-ply with the edge of the cutter to start removal:

1.



2.



3.



==> Get cutter blade under peel-ply

Tear off the peel-ply for the full width of the laminate:

1.



2.



3.



4.



5.



6.



==> Aim for the following



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Remove the full length of peel-ply on the required length of laminate:



Until you get the clean laminate, without peel-ply.