



WORK GUIDELINE No. 13

CFRP (Carbon Fiber Reinforced Polymer) Application of Carbon Fiber Sheet and Carbon Lamellas to concrete surfaces

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1 Purpose

The purpose of the present Work Guideline is to introduce the static strengthening of reinforced concrete bridge superstructures by CARBONFORCE® (SINIT carbon sheets and carbon lamellas epoxy technology).

Preliminary conditions, surface preparation and inspection, application of carbon sheets and carbon lamellas and quality assurance of both applied materials and executed works are described.

2 Reference documents

Bridge design.

Bridge superstructure strengthening design.

For application of carbon sheets refer to Sinit Technical Data Sheet Adh/2 for **E/2** (Epoxy Adhesive), Aux/1 for **THK 2** (Thickening Agent) and Coat/3 for **#777 COAT** (General purpose concrete epoxy coating).

For application of carbon lamellas refer to Sinit Technical Data Sheet Adh//1 for **P.A. 103** (Epoxy Adhesive) and Coat/3 for **#777 CAOT** (General purpose concrete epoxy coating) .

3 Preliminary conditions

The following preliminary conditions shall be fulfilled prior to applying carbon sheets and carbon lamellas:

- Workers involved in applying carbon sheets and carbon lamellas shall be adequately trained and skilled.
- Safe accesses and suitable work scaffolds shall be arranged.
- Concrete surface to which carbon sheets and carbon lamellas will be applied must be prepared in accordance with the laminate maker's instructions.
- Concrete adhesion strength measured according to the pull-off method shall not be less than 1.5 N/mm².
- Position where carbon sheets and carbon lamellas shall be applied, must be clearly marked on the concrete surface.
- During application of carbon sheets and carbon lamellas both air and concrete temperature must not be lower than +5°C or higher than +35°C.
- Concrete moisture content shall not exceed 3% by weight.
- Air temperature shall be by at least 3°C above the dew point.
- All the required equipment and tools shall be present at site, such as:
 - working space for preparation of carbon sheets and carbon lamellas (cutting, cleaning, application of adhesive);
 - mechanical mixer for epoxy adhesive;
 - trowels of different widths;
 - stainless steel smoothing trowel;
 - automatic thermo-hydrograph for measuring both temperature and relative humidity;
 - gauge for measuring concrete humidity;
 - gauge for measuring concrete temperature;
 - roller for pressing carbon sheets;

- roller for pressing carbon lamellas;
- mould for taking specimens of SINIT adhesives.

4 Concrete surface preparation and inspection prior to applying carbon sheets and carbon lamellas.

Prior to applying carbon sheets and carbon lamellas, the concrete surface shall be prepared as specified below:

- Concrete surface shall be washed with a 400 bar high-pressure water-jet to remove laitance, warts, biological impurities such as moss, algae and lichen. If necessary, degreasing shall be carried out as well. The surface roughness shall be between 0.5 mm and 1.0 mm.
- After washing of the concrete surface is completed, the latter shall be inspected to identify deficiencies such as:
 - unevenness of the concrete surface shall not exceed 10 mm. over 2.0 m. length. If this is not the case, the surface shall be levelled with epoxy adhesive paste P.A. 103 or epoxy mortar formed by E/2 (Epoxy Adhesive) and quartz sand;
 - all crests in areas of joints between formwork elements shall be ground; the surface roughness shall be between 0.5 mm and 1.0 mm;
 - local hollows and porosities shall be filled with epoxy adhesive P.A. 103 or E/2 (Epoxy Adhesive) added with THK 2 (Thickening Agent).
 - concrete cracks of a width greater than 0.2 mm shall be injected with epoxy INJECTION 1; structural Designer shall be informed of eventual presence of cracks immediately;
 - all useless foreign materials such as wood, wire remains, nails etc. incorporated in the concrete shall be removed.
- Exact positions of areas where to apply carbon sheets and carbon lamellas shall be outlined;
- Concrete adhesion strength shall be measured according to the pull-off method in the areas where carbon sheets and carbon lamellas shall be applied. No measured value shall be less than 1.5 N/mm².

5 Preparation of carbon sheets and carbon lamellas and their application.

5.1 Preparation of carbon sheets for application.

Carbon sheets shall be cut to the specified length. On each roll there are the manufacturer's information on type, quality and weight. Both sides on the carbon sheets are good for

application of the adhesive. To prevent soiling carbon sheets shall be put on a suitable podium of adequate length.

5.2 Preparation of carbon lamellas for application

Carbon lamellas shall be cut to the specified length. On the smooth side of the laminate there are manufacturer's information on type, quality and weight. The adhesive shall be applied to the other side after the latter has been slightly roughened by sand paper to remove the outer matrix and thoroughly cleaned with a cloth soaked with SINIT OMNIA Solvent. To prevent soiling carbon lamellas shall be put on a suitable podium of adequate length.

5.3 Application of SINIT E/2 epoxy adhesive and application of carbon sheets.

5.3.1 Application of adhesive to concrete surface.

E/2 Liquid Epoxy Adhesive added with the required quantity of THK 2 Thickening Agent shall be applied to the concrete surface where carbon sheets will be subsequently glued. The adhesive shall be applied and pressed to the prescribed area by a short haired roller or spatula to a thickness of approximately 1 mm. Carbon sheets shall be glued while E/2 Epoxy Adhesive is still tacky, which means within the "open time" of the adhesive itself. "Open time" is the maximum time allowed from start of mixing to placement of element to be bonded. Average consumption of E/2 Liquid Epoxy Adhesive plus THK 2 Thickening Agent is 1.2 kg./sqm.

5.3.2 Application of carbon sheets to the concrete surface.

The carbon sheets shall be glued and pressed with a rubber roller to the concrete surface to which the adhesive has been already applied. Once the carbon sheet is stuck to the concrete surface it must be impregnated to saturation with adhesive by a short haired roller. Adhesives applied to the concrete must be tacky, which means within the "open time" of the adhesive itself. "Open time" is the maximum time allowed from start of mixing to placement of element to be bonded.

5.4 Application of SINIT P.A. 103 epoxy adhesive and application of carbon lamellas.

5.4.1 Application of adhesive to concrete surface.

P.A. 103 Adhesive Epoxy Paste shall be applied to the concrete surface where carbon lamellas will be subsequently glued. The adhesive shall be applied and pressed to the prescribed area by a metal spatula to a resulting final thickness of approximately 1 mm. Carbon lamellas shall be glued when P.A. 103 Epoxy Adhesive is still tacky, which means within the "open time" of the adhesive itself. "Open time" is the maximum time allowed from start of mixing to placement of element to be bonded. Average consumption of P.A.103 Adhesive Epoxy Paste is 2.4 kg./sqm.

5.4.2 Application of adhesive to carbon lamellas.

P.A. 103 Adhesive Epoxy Paste shall be applied to the carbon lamellas by spatula. The adhesive shall be applied to a uniform thickness of about 2 mm. in order to fill any small cavity in the concrete.

5.4.3 Application of carbon lamellas to the concrete surface.

The carbon lamellas to which the adhesive has already been applied shall be glued to the concrete surface to which the adhesive has been already applied. Both adhesives applied to carbon lamellas and to concrete must be tacky, which means within the “open time” of the adhesive itself. “Open time” is the maximum time allowed from start of mixing to placement of element to be bonded.

The carbon lamellas must be pressed to the substrate from one end to the other with a rubber roller to press out the surplus adhesive. Along the laminate edges, the pressed-out adhesive shall be skimmed with a spatula to form a sort of chamfer.

The laminate surface can be cleaned with a cloth soaked with SINIT OMNIA solvent.

5.5 Applying of intersecting carbon lamellas

In areas where carbon lamellas intersect, i.e. they run one over another, applying shall be carried out as follows:

- The adhesive of the lower carbon lamellas shall already be cured.
- In the area where carbon lamellas intersect, the upper surface of the lower, already glued laminate, must be slightly roughened by sand paper and cleaned with SINIT OMNIA Solvent.
- On the intersecting surface the SINIT P.A. 103 Epoxy Adhesive shall be applied in a thickness equal to the carbon lamellas thickness to level the surface prior to applying the upper carbon lamellas.
- Transverse carbon lamellas shall be applied in compliance with item 5.4.

6 Painting carbon sheets and carbon lamellas and surfaces in-between

To achieve an appropriate aesthetic appearance, when not covered by plaster or mortar, the complete sheet and/or carbon lamellas surface and the surface between Carbon Sheet and Carbon Lamellas shall be painted with SINIT #777 COAT (General Purpose Concrete Epoxy Coating) or FSS COAT ELASTIC (water-based acrylic protective and decorative paint) of the appropriate RAL colour shade. Two paint coats shall be applied.

7 Quality assurance of applied materials and executed works

The following activities shall be performed to assure quality of applied materials and executed works:

- Inspection of concrete surfaces after high-pressure washing.
- Measuring concrete adhesion strength (pull-off test).
- Measuring temperature during the works.
- Measuring concrete moisture content prior to applying carbon lamellas.

- Taking adhesive specimens for current control.
- Acquiring certificates of applied materials.
- Working out a final report on works accomplished.