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Date: 09/2004

Construction

Method Statement
Structural Strengthening

Corporate Construction

Scope:
SikaWrap Fabric System: Preparation and Application

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1. SikaWrap System Description

The SikaWrap Composite System is a High Performance Strengthening System containing FRP Fabrics and Impregnation Resins. They are applied on the strengthening site and formed to a fiber composite.

- The main range of applications are as follows:
- Increasing loading capacity of structural elements
- Shear strengthening
- Flexural strengthening
- Masonry strengthening
- Column strengthening (Confinement and / or Ductility)
- Changes of building utilization
- Structural upgrading to comply with current standards
- Improved serviceability

- General seismic upgrading and retrofitting
- Prevention of defects caused by seismic action
- Improved seismic performance of masonry walls
- Blast mitigation (accidents or terrorism)
- Impact protection

- Structural design construction defects
- Substitute missing rebars

2. Strengthening Materials

2.1 SikaWrap FRP (Fiber Reinforced Polymer) Reinforcements

SikaWrap fabrics are available based on three different types of fibers and areal weights. The elastic modulus of the fibers cover a range from 70 to 640 GPa.

Packaging:

- The fabric rolls are wrapped in PE sheets and individually packed in cardboard boxes
- Areal weights between 160 and 955 g/m^2
- Roll length: 50 meter
- Roll width: 300 and / or 600 mm

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Woven Fabric Types:

- SikaWrap-xxxC — Unidirectional, carbon fiber based fabrics
- SikaWrap-xxxC 0/90 — Bi-directional, carbon fiber based fabrics
- SikaWrap-xxxG — Unidirectional, E-glass fiber based fabrics
- SikaWrap-xxxA — Unidirectional, Aramid fiber based fabrics

Non-woven Fabric Types:

- SikaWrap-xxxC NW — Unidirectional, carbon fiber based fabrics

Product Name	Fiber Type	Areal Weight [g/m^2]	Fiber Stiffness [GPa]	Fiber Strength [MPa]	Fiber Strain [%]	Fiber Density [g/cm^3]	Nominal Thickness [mm] *	Preferred Application Method ***
SikaWrap-200C	C	200	230	3900	1.5	1.79	0.111	Dry
SikaWrap-230C	C	230	238	4300	1.8	1.76	0.131	Dry
SikaWrap Hex-230C	C	220	230	4100	1.7	1.78	0.122	Dry
SikaWrap-300C	C	300	230	3900	1.5	1.79	0.166	Dry / Wet
SikaWrap-201C	C	200	230	4900	2.1	1.80	0.110	Dry
SikaWrap-231C	C	230	230	4900	2.1	1.80	0.127	Dry
SikaWrap-301C	C	300	230	4900	2.1	1.80	0.167	Dry / Wet
SikaWrap-103C	C	610	230	3900	1.5	1.79	0.337	Wet **
SikaWrap-160C 0/90	C	160	230	3800	1.5	1.75	0.046/ 0.046	Dry
SikaWrap-200C NW	C	200	230	3900	1.5	1.79	0.111	Wet
SikaWrap-300C NW	C	300	230	3900	1.5	1.79	0.166	Wet
SikaWrap-400C MidMod NW	C	400	392	2600	0.6	1.81	0.191	Wet
SikaWrap-300C HiMod NW	C	300	640	2600	0.4	2.12	0.140	Wet
SikaWrap-400C HiMod NW	C	400	640	2600	0.4	2.12	0.187	Wet
SikaWrap-100G	G	935	76	2300	2.8	2.56	0.358	Wet **
SikaWrap-107G	G / A	955	76	2300	2.8	2.56	0.347 (UD)	Wet **
SikaWrap-430G	G	430	76	2300	2.8	2.56	0.172	Dry
SikaWrap-300A	A	300	100	2880	2.8	1.44	0.206	Wet
SikaWrap-450A	A	450	100	2880	2.8	1.44	0.309	Wet

* Nominal areal weight divided by the fiber density
** Use of a saturator recommended for impregnation
*** The wet application method is an option for all types but not recommended for the woven fabrics with low areal weights

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2.2 Sikadur Primers / Impregnation Resins

Sikadur-300:	Low-viscous, unfilled primer / impregnation resin with an extra long pot life and a slow curing speed. To be used with the wet application method preferably.
Sikadur-330:	Mid-viscous, small particle filled epoxy-based primer / impregnation resin with standard pot life and curing speed. To be used with the dry application method preferably.

2.3 Supplementary Products

• Sikadur-30	Epoxy-based structural adhesive paste
• Sikadur-41	Epoxy-based repair mortar
• Sikadur-52	Epoxy-based injection resin
• Sikadur-501	Quartz sand
• Sikadur-513	Thixotropic agent
•	
• Sikagard-Sikagard-550W Elastic	One-part, plasto-elastic coating based on UV-curing acrylic dispersion with excellent crack-bridging properties
• Sikagard-670W	One-part, water-dispersed, acrylic, protective, anti-carbonation coating
• Sikagard-Elastocolor-675W	One-part, plasto-elastic water dispersed coating based on acrylic-styrene acrylate for concrete protection.
• Sikagard-680S	One-part, solvent containing coating based on acrylic resin resistant to weather and alkali aging.
• SikaWrap Plastic Impregnation Roller	Ripped Fabric Lamination Tool
• Saturator	Aid for mechanical fabric saturation

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3. Pre-Project Preparation

3.1 General

Review project specifications in detail. Inspect surfaces to receive the work and report immediately in writing to the Engineer as required in the General Conditions and deficiencies in the surface which render if unsuitable for proper execution of this work.

Obtain all equipment and materials as per checklist and any special project requirements. It is recommended that the fabrics to be applied shall be cut beforehand with sharp scissors into prescribed lengths in advance of the mixing of the resin. Caution should be taken in fabric handling to insure that the fibers are not bent or broken. Do not fold fabrics.

Protect vehicles, concrete, and other items surrounding work area from dust or damage due to preparation or strengthening works.

3.2 Bonding works

The SikaWrap systems may only be used by experienced professionals.

The system configuration as described in the Product Data Sheets must be fully complied with and may not be changed.

Record batch numbers for SikaWrap fabric and Sikadur resin used each day. Check to make sure fabric is applied uniform and smooth.

Large mixing quantities and /or high temperatures result in shortening of the pot life. In order to prolong the pot life, reduce the quantity of the mixing components and/or the material's temperature.

For application in cold or hot conditions, pre-condition material for 24 hours in temperature controlled storage facilities to improve mixing, application and pot life limits.

Special attention should be paid at ambient conditions. Observe min. / max. temperatures for substrate, atmosphere and materials as well as dew point (Application temperature > dew point +3 °C)

Substrate moisture must be less than 4 %.

All concrete surfaces shall be dry free of surface moisture and frost.

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4. Safety Measurements on Site

Wear always protective clothing (gloves, glasses, closed overall, hat). For detailed information please ask for relevant safety data sheets which has to be present on site.

4.1 Cleaning

Clean all equipment each day. Uncured epoxy should be wiped up with a rag wetted with solvent.

4.2 Disposals

Cured primers / resins shall be removed by mechanical means and properly disposed.

Uncured primers / resins may be cleaned from tools with an approved solvent and properly disposed. If there is any uncured epoxy left at the end of the day, pour it out thinly on a flat polyethylene lined surface where it will cure safely overnight without causing excess heat as it would do in a pail.

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5. Surface Preparation, Quality Control

5.1 Substrate Preparation

The surface must be dry and free of deteriorated concrete, bond inhibiting materials and contaminants as dust, foreign particles, laitance, oil, grease, coatings, curing compounds, waxes and impregnation.

Concrete, stone and masonry substrates must be prepared mechanically using abrasive blast cleaning or grinding equipment. This will remove cement laitance, loose and friable material to achieve a profiled open textured surface. Surface defects such as honeycombed areas, blowholes and voids must be fully exposed by grinding.

Timber substrates must be planed or sanded. All dust, loose and friable material must be completely removed from all surfaces.

All prepared surfaces shall be air blasted and vacuumed clean with an industrial vacuum cleaner to a dust free condition.

Inject cracks wider than 0.25 mm with Sikadur-52 or other suitable Sikadur-injection resin.

External corners must be generally rounded to a minimum radius of 20 mm or as per the design specification. This can be achieved either by grinding or by building up with Sikadur mortars. Internal corners shall be smoothed by trowelling epoxy mortar into the corners.

The surface to be bonded must be level (max. deviation 2 mm per 0.3 m length), with steps and formwork marks not greater than 0.5 mm. High spots can be removed by abrasive blasting or grinding.

Repairs to substrate and concrete surface irregularities such as blowholes or voids shall be filled with an approved repair mortar. Sikadur-41 or a mixture of Sikadur-30 and Sikadur-501 quartz sand (mix ratio 1:1 max. parts by weight) serves best.

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5.2 Preparation Quality Control

Bond tests must be carried out to ensure substrate preparation is adequate. The substrate must be of sufficient tensile strength to provide a minimum pull-off strength of 1.0 N/mm^2 unless otherwise indicated by project specification requirements.

5.2.1 Tensile Pull-Off Test

Prepare the surface to be tested as described. Core drill down 5-10 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 an island-type core with a diameter of 50 mm. This size corresponds to the dolly outer diameter.

The bottom surface of the metal dolly has to be grit blasted or roughened with sandpaper and be cleaned and free from any grease. Mix the epoxy components according to the recommendations just prior to use. Apply the mixed adhesive to the core surface and to the bonding face of the dolly. Place the dolly on the core and let the adhesive cure.

Attach a pull-off tester to the dolly such that a load can be applied at right angles to the surface. Zero the machine and increase the load until the specimen fails. This 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 described and recorded. The average of the values shall be taken as a pull-off strength result.

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6. Resins, Mixing

Ground substrates are generally 'smooth', abrasive blast cleaned ones more 'rough'. This difference is the deciding factor for the type of primer resins.

Smooth surfaces: liquid resins as Sikadur-300 can be used to prime.

Rough surfaces: filled resins such as Sikadur-330 are suited to bridge the irregularities of rough surfaces. Sikadur-300 can be mixed with max. 5 % thixotropic agent Sikadur-513 to fulfil the same requirements.

6.1 Resin / Primer Sikadur-300

Sikadur-300 has an extra long pot life and a slow curing speed.

6.1.1 Mixing

Mixing ratio A:B=100:34.5 by weight

Standard Packs:
Continuously mix all of Part A in container then gradually add all of Part B at a low speed (max 500 rpm) for 3 minutes.

Industrial Packaging:
Full quantity: continously mix all of Part A in container then gradually add all of Part B.
Partial quantity: weigh the correct proportions of Parts A and B and pour into clean container before mixing.

6.2 Resin Sikadur-330

Sikadur-330 serves as primer and impregnation resin for the fabrics.

6.2.1 Mixing

Mixing ratio Sikadur-330: A:B = 4:1 by weight.

Standard Packs:
Continuously mix all of Part A in its container at a low speed (max 500 rpm) then gradually add all of Part B until a uniform mix has been achieved. Then pour the whole mix into a clean container and mix for a second time.

Industrial Packaging:
Weigh the correct proportions of Parts A and B and pour into separate clean containers before mixing by the same method as for the standard packs.

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7. FRP Reinforcement Application

7.1 General Remarks

Avoid excessive force and moving the roller back and forth when laminating to prevent folding or creasing of the SikaWrap fabric.

Fiber direction overlapping must be at least 100 mm or according to the fabric applied or as per the project specifications.

Side by Side Application:
Unidirectional fabrics: when placing several unidirectional SikaWrap fabrics side by side no overlapping is required unless specified in the strengthening design.
Multi-directional fabrics: overlapping in the weft direction must be at least 100 mm (depending on the SikaWrap fabric type) or as per the project specifications

7.2 Dry Application Method

The dry application method is named because of the state of the fabric in the moment it is applied to its final position.

The dry application method is suited for woven fabrics with an areal weight of 300..450 g/m^2, depending on the fiber type.

7.2.1 Primer / Resin Application

Because Sikadur-330 serves as primer and impregnation resin at the same time, one application step can be left out.

Apply Sikadur-330 to the prepared substrate using a trowel, roller or brush.
Consumption 0.5 to 1.0 kg/m^2, depending of the roughness of the substrate.

7.2.2 Fabric Placement / Lamination

Follow manufacturer's recommendations regarding Sikadur-330 open times. The fabric application must take place wet on wet.

Place the pre-cut dry SikaWrap fabric in the required direction onto the Sikadur-330 primer.

Carefully work the fabric into the resin with the Sika plastic impregnation roller parallel to the fiber direction until the resin is squeezed out between and through the fiber strands and distributed evenly over the whole fabric surface.

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7.2.3 Additional Fabric Layers

The application of additional layers must take place wet on wet.

At low temperatures and / or high relative humidity, a tacky residue (blush) may form on the surface of the cured Sikadur-330 epoxy. If an additional layer of fabric, or a coating is to be applied onto the cured epoxy, this residue must first be removed to ensure adequate bond. The residue can be removed with water. In both cases, the surface must be wiped dry prior to application of the next layer or coating.
The quantity of additional Sikadur-330 to be applied to the already installed layers is depending on the fabric type.

For additional layers of SikaWrap fabric, apply Sikadur-330 to previous applied layer wet on wet within 60 minutes (at +23 °C) after application of the previous layer and repeat laminating procedure. If it is not possible to apply within 60 minutes, a waiting time of at least 12 hours must be observed before application of the next layer.
Overlapping sections of the additional layers should be distributed over the column circumference.

7.2.4 Preparation for Cementitious Overlays / Coloured Coatings

At low temperatures and / or high relative humidity, a tacky residue (blush) may form on the surface of the cured Sikadur-330 epoxy. If an additional layer of fabric, or a coating is to be applied onto the cured epoxy, this residue must first be removed to ensure adequate bond. The residue can be removed with water. In both cases, the surface must be wiped dry prior to application of the next layer or coating.

If a cementitious overlay is to be applied over the SikaWrap fabric an additional Sikadur-330 resin layer must be applied over final layer at a max. 0.5 kg/m^2.

Broadcast with quartz sand while wet which will serve as a key for the overlay.
If a coloured coating is to be applied the wet Sikadur-330 surface can be smoothed with a brush.

7.3 Wet Application Method

The wet application method is named because of the state of the fabric in the moment it is applied to its final position.

The wet application method is suited for the non-woven fabrics as well as for any woven fabric, especially with an areal weight of higher than 300..450 g/m^2, depending on the fiber type.

Follow manufacturer's recommendations regarding waiting times between the different primer / resin application steps.

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7.3.1 Primer Application

Primer application is the same procedure for manual impregnation or mechanical saturator impregnation.
Apply the primer to the prepared smooth substrate with a trowel, brush or a mohair roller. Apply a second coat as necessary after first coat has penetrated into concrete.

7.3.2 Resin Application

Resin consumption is about 0.4 to 1.0 kg/m^2, depending on the SikaWrap fabric type.

7.3.2.1 Manually

Distribute 2/3 of the expected Sikadur-300 quantity on a clean PE sheet and then place the pre-cut fabric onto the resin covered sheet. Saturate SikaWrap fabric by rolling with a mohair roller in the fiber direction. Distribute the remaining 1/3 of the Sikadur-300 onto the fabric and evenly spread with roller to fully saturate fabric.
The resin consumption can be checked by taking the weight of the fabric before and re-weighing after wetting with Sikadur-300.

7.3.2.2 Manually, Non-Woven Fabrics Option

Apply 2/3 of the expected Sikadur-300 quantity onto the primed substrate by roller or spray. Leave the yellow backing sheet on the fabric during the resin application process.

7.3.2.3 Mechanically with Saturator

Equipment should be located in a well-ventilated and well-lighted area.
Set-up of saturator shall be supervised and checked by the properly trained foreman as per the manufacturer's instructions.

Follow Manufacturer's procedures for proper machine set-up and calibration. Rollers shall be calibrated to saturate the fabric with the correct resin-to-fabric ratio.

Saturating procedure:

Adjust the white plastic resin dams to the correct width of the fabric.

The gap width adjustment between the rollers is made by turning the handles attached to the threaded rods. Use shims/feeler gauge to measure the gap. Once it is determined correctly, tighten the locking nuts on the adjusting bolts

The gap widths should be checked at the beginning of each day by a qualified technician for accuracy in case the rollers shifted during use.
Use the table below to determine the starting gap width. A too narrow gap will 'crush' the fabric and a too wide gap will result in 'too wet' fabric.

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Large temperature variations will affect the viscosity of the epoxy resin and therefore the gap width. Recommended starting gap widths for saturating with Sikadur-300:

Fabric type	Roller gap width at 23 °C [mm]
SikaWrap-100G	1.20
SikaWrap-107G	1.20
SikaWrap-103C	1.10

- Have pre-cut fabric ready or roll of fabric positioned on the saturator.
- Wet the rollers by pouring a bead of Sikadur-300 in the center of the rollers, while slowly rotating them inward. Pass the fabric over the top bar and through the rollers and take it up onto the winding tub
- Slowly rotate the saturator rollers continuously.
- Keep Sikadur-300 reservoir full during saturation by continuously pouring resin onto the rollers on both sides of the fabric
- Keep fabric scissors near. Once the fabric is saturated, it can be spooled for easy handling. Care must be taken not to damage the fibers.
- Remove the plastic winding tube (spool) containing the saturated SikaWrap fabric. Have extra winding tubes ready.
- E-glass fabric is saturated when it appears clear and you can 'see' through it. The surface of the carbon fabric will have a sheen to it and still appear to have some texture when it is saturated.

7.3.3 Fabric Placement / Lamination

Place the pre-wetted, saturated SikaWrap fabric onto the primed wet surface in the required direction (within the open time of the primer) and smooth by hand to remove folds and creases.

After smoothing and placement, the fabric is laminated onto the substrate using the Sika plastic impregnating roller. Pass the roller over the fabric parallel to the fiber direction until the resin is distributed evenly over the fabric and entrapped air is released. Avoid excessive force when laminating to prevent folding or creasing of the SikaWrap fabric.

Remove the yellow backing sheet of the non-woven fabrics and roll again gently.

If additional layers are required repeat the impregnation and laminating process. The application must take place wet on wet.

Apply sealing layer of Sikadur-300 approximately 0.3 kg/m^2 and broadcast quartz sand while wet in order to achieve the required roughness for the plaster to follow. The application must take place wet on wet.

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7.3.4 Additional Fabric Layers

The application of additional layers must take place wet on wet.

The quantity of additional Sikadur-330 to be applied to the already installed layers is depending on the fabric type.

For additional layers of SikaWrap fabric repeat laminating procedure. Follow manufacturer's recommendations regarding waiting times.

The overlapping sections of the additional layers should be distributed over the column circumference.

7.3.5 Preparation for Cementitious Overlays

If a cementitious overlay is to be applied over the SikaWrap fabric an additional Sikadur-300 resin layer must be applied over final layer at a max. 0.3 kg/m^2.

Broadcast with quartz sand while wet which will serve as a key for the overlay.

7.4 Coloured Coating

This section is equal for the dry application and the wet application methods (manual and saturator impregnation).

The applied and cured SikaWrap fabric can be coated with a coloured protective coating for aesthetic and/or protective purposes. Selection will be dependent on exposure requirements. For basic UV protection use Sikagard-550W Elastic, Sikagard-670W, Sikagard Elastocolor-675W or Sikagard-680S.

Follow manufacturer's recommendations regarding waiting times before coating.

7.5 Curing

Protect finished installation of FRP Reinforcement from rain, sand, dust and other contaminants using protective foils or other barriers. Do not allow protective foil to come in contact with finished application.

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8. Inspection, Sampling, Quality Control

8.1 Site Inspection

The inspection agency shall continuously observe all aspects of preparation, mixing, and application of materials, including the following:

- Surface preparation
- Material container labels
- Mixing of resin
- Application of resin to the fiber
- Curing of composite materials
- Testing of samples.
- All aspects related to the FRP) Reinforcement

Upon completion of the curing process the installed system shall be checked for areas where impregnation resin has not penetrated or where resin has not completely cured. Such areas covering more than 25 x 25 mm of the surface area shall be resin injected to reestablish bond subject to the specification and approval of the engineer.

All repairs shall be subject to the same application, curing and quality control specifications as the original work. The following types of repairs are recommended:

For small delaminations and bubbles inject with a system compatible epoxy.
If large defects are found, the application of additional layers of FRP Reinforcement may be necessary. The preparation works, number of layers to be added and the overlap length shall be approved by the project engineer.

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8.2 Sampling and Testing

The fabric sampling procedure shall be followed as required by job specifications.

- Record lot / batch / roll number of fabrics used for wrapping
- Resin components shall be taken from the same lots as will be used for construction
- Sample Size: 30 x 30 cm or as required
- Saturate fabric (either by using hand saturating procedures or by running fabric and epoxy through properly set saturator)
- On a smooth flat level surface, covered with a polyethylene sheet with 0.5 mm thickness, place the required number of layers of SikaWrap fabrics in the same direction.
- Samples should be cured and not moved for 48 hours after installation. Use disposable gloves when handling samples.

Send engineer-selected samples to a pre-qualified laboratory. The laboratory must return results within a maximum of ten days. The prepared, identified samples shall be tested at random as per engineer's or owner's requirements. The testing shall consist at least of the following:

- Ultimate tensile strength
- Tensile modulus
- Strain at break

The detailed testing is described in the two standards ISO 527-5 and ASTM D3039/D3039 M.

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