# A lasting bond

**Module bonding |** PV modules are commonly installed with mechanical fixings. But as installers look to drive down system costs, structural bonding is emerging as a reliable and cost-effective alternative, writes Michael Niederfuehr

Source: Sika Services.

**A 3.1MW on-site bonded project in Bari, one of Italy's largest PV installations.**

For approximately half a decade, cost pressure on photovoltaic power generation has remained at an exceptionally high level. This fact forces the PV industry to find innovative and cost-effective solutions across the value chain – from wafer production to module installation.

The sub-construction and installation of PV modules represent a major share in the cost structure of PV power plants, both small scale and also utility scale.

Commonly, PV modules are installed using mechanical fixing devices, which clamp the modules' edges or frames usually to metal sub-constructions on a roof or on a greenfield installation.

As an alternative to mechanical fixation, structural bonding offers very attractive features which can help to gain notable cost savings regarding installation effort and sub-construction.

The cost savings either come from the very fast installation or moreover from a significantly optimised sub-construction, provided that the PV modules are, by design, considered as an integral part of the whole assembly.

A perfect example for gaining maximum benefit of bonding technology for PV module installation is the direct bonding of PV modules to corrugated steel roof claddings without any sub-construction involved. In this case, the backside of the PV module is directly bonded on to the corrugations of the sheet metal roof claddings using suitable adhesives.

Such suitable adhesives offer both structural properties – to assure long-term mechanical integrity – and also flexible properties – to assure stress-free compensation of relative dilatation of the bonded elements due to different thermal expansion rates. Due to the perfect electrical insulation properties of the adhesives, grounding can be prevented. In addition, the lean as well as fast installation, and the maximum area utilisation of the roof, allow further cost savings and maximum energy harvest.

The low static weight and the perfect watertight roof due to eliminated penetration of the sheet-metal roof claddings, which is necessarily required for mechanical fixation, bring additional value. Besides these cost savings the equal load distribution of bonded joints reduces stress concentration in the PV module's superstrate (mostly glass) and hence helps to reduce local cell breakage or even breakage of the glass layer and further helps to extend the lifetime of PV modules.

The nonexistence of frames and clamps and thus stepped edges makes it more difficult for efficiency-reducing dirt, soiling, snow or debris to attach to the glass or the clamps as there is no risk of retention at those stepped edges or clamps respectively. Also the O&M costs are positively affected by directly bonded PV modules: the 'improved flatness' without protruding parts makes the PV modules easier to clean without getting stuck with the cleaning device.

The favourable adhesive technology for such on-site bonding applications is silicone – usually one-component, moisture-curing silicone adhesive. This is because it requires less sophisticated application equipment without need for a mixing device.

Generally, silicone adhesive technology is preferred mainly for the following reasons: easy handling and outstanding longevity due to chemical inertia with regard to UV-radiation and outdoor conditions. The chemical inertia is the root cause for the insignificant degradation of the adhesive's mechanical, physical and chemical performance even under harsh ambient conditions such as high relative humidity and heat, or an acidic atmosphere which can occur at coastal areas or at installation sites adjacent to heavy-industrial areas.

Structural silicone adhesives with excellent weather resistance have been successfully and site-independently proven for decades, for example in structural glazing applications for high-rise buildings.

Provided that the project was executed according to state-of-the-art procedures, a load-bearing function of the adhesive joints can be considered over the PV module's intended lifetime of approximately 25 years.

## Bonding procedures

As already mentioned, silicone adhesives often demand a clean surface only, whereas

Source: Sika Services.

**Detail of a structurally bonded backrail.**

Source: Sika Services.

**Backside of on-site-bonded PV modules as part of a greenfield PV installation.**

other adhesive technologies require not only cleaning but also priming of the bonding area. Of course, the fundamental suitability of the substrates with regard to adhesion build up and longevity needs to be proven for the actual substrates. The main criterion for the approval is the doubtless proof of adhesion before and after application-relevant ageing conditions according to construction and PV standards, e.g. EOTA ETAG 002 or IEC 61215/61646 respectively.

After successful testing and substrate approval, one of the most crucial parameters required to be controlled is the substrates' quality. For a reliable and long-lasting bond, a consistent surface quality is absolutely mandatory. Dependent on project size and in case of a system approval, the elaboration of a specification, i.e. defining the surface quality of the elements to bond, is advisable in order to minimise the risks of varying substrate quality and of varying adhesion performance. In case of bonding directly on corrugated sheet metal roof claddings, also the approval of the roof cladding supplier regarding additional load is advisable. In any case, local regulations and standards have to be exactly followed.

Older substrates, which have been exposed to random ambient conditions, are generally out of scope for being bonded on, as in this case, the substrates cannot be considered as consistent and defined. As an example, just imagine an industrial building, erected several years ago: areas next to chimneys are affected by the fallout of exhaust products, areas under or next to trees can be affected by contamination with tree resin or residues from fallen leafs, unshaded areas are mainly affected by influence of solar irradiation – all these conditions can occur, even within on continuous roof area.

As a result, PV modules always need to be bonded straight after erection of the roof or of the sub-construction respectively. Of course, this is not viable for every project and for such cases there is only one option: a defined interface for bonding has to be created, for example by riveting aluminium rails to the corrugated roof, that must be instantly bonded on

The cleanliness of the surface also plays an important role in overall consistency and must be assured by cleaning the bonding areas prior to applying the adhesive, as per the definition based on the adhesion testing.

## Bonding challenges

To be fair, structural bonding of PV modules on-site does present some challenges and limitations. The major limitation is the dependency on ambient conditions during installation. Like other construction works where chemical products are involved, on-site bonding is somewhat dependent on weather conditions: installation during rain or snowfall, freezing temperatures or in the case of extreme hot ambient and surface temperatures – depending on the preferred adhesive system – is absolutely not advisable. The actual temperature limits may vary slightly with the actual adhesive system used, however these values can be considered as a rule of thumb for commonly used, neutral curing silicone adhesives.

Especially if temperatures are hardly above 5 degrees Celsius and/or the relative humidity level is very high, also the dew point has to be respected as there is a risk of water condensation on the substrates which could hinder the wetting of the substrates with adhesive. Temperatures below 5 degrees Celsius greatly delay flash-off of the cleaning agents and further delay the curing of the adhesive since mostly moisture curing silicone adhesives are used for on-site bonding applications. In case of high temperatures, especially during high solar irradiation on the usually dark coloured PV modules, there is a potential risk of exceeding the maximum allowed curing temperature, which may lead to bubble formation of the uncured adhesive inside the joint. This could finally weaken the cross-section of the adhesive joint after full cure.

All of this underlines the fact that the whole bonding process needs to be planned properly and adapted to actual site conditions, including clear definitions of all the points mentioned above and beyond. Furthermore, everything needs to be documented in working instructions which define all relevant steps to be followed and their actual limitations. As part of the working instruction, in addition a suitable quality control procedure needs to be put in place to assure a smooth and faultless installation process and thus reliable structural bonded joints. Such QC procedure is based on established procedures borne from structural glazing applications with similar requirements and demands with regard to application, lifetime and safety.

Of course, as with the installation of mechanically fixed PV modules or any other professional work, the installation should be executed by well-trained professional staff only, to assure correct execution of the bonding application.

Last but not least, and as valid as for any other technical device, there is a definite need for a specific maintenance programme for bonded PV modules, reflecting the special needs of bonded elements. Depending on specific environmental factors, such as the presence of leafs, frequency of rainfall, moss growth etc, cleaning on a regular basis is mandatory to enjoy the utmost lifetime of the PV power plant. In particular, excessive dirt accumulation underneath the PV modules, in combination with humidity or even standing water, may harm the polymeric components of the bond and above all pose a potential electrical shock hazard if the moisture finds an access point to a live part.

Summing up the above, structural on-site bonding of PV modules is a cost-competitive, technically advantageous and reliable alternative for PV module installation compared to mechanical fixation, provided that the bonding technology has been fully understood, the project is properly planned and simple basic rules have been respected. ■


### Author

Michael Niederfuehr is a market field engineer for Sika Services, with responsibily for bonding technology in international solar projects.