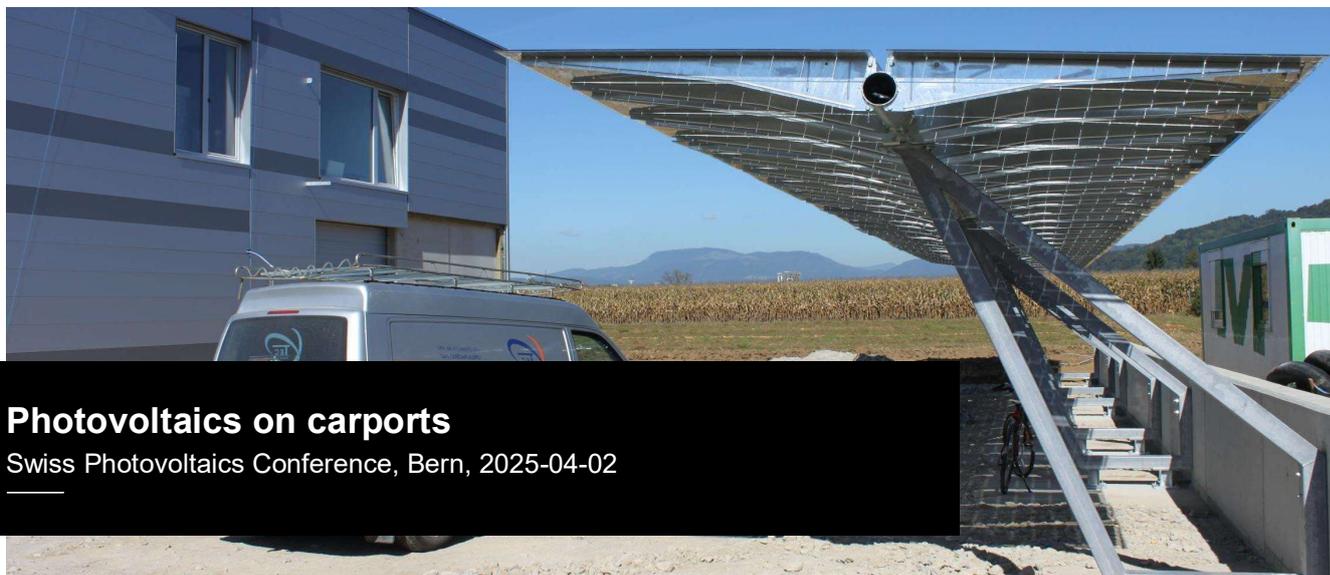


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Photovoltaics on carports

Swiss Photovoltaics Conference, Bern, 2025-04-02

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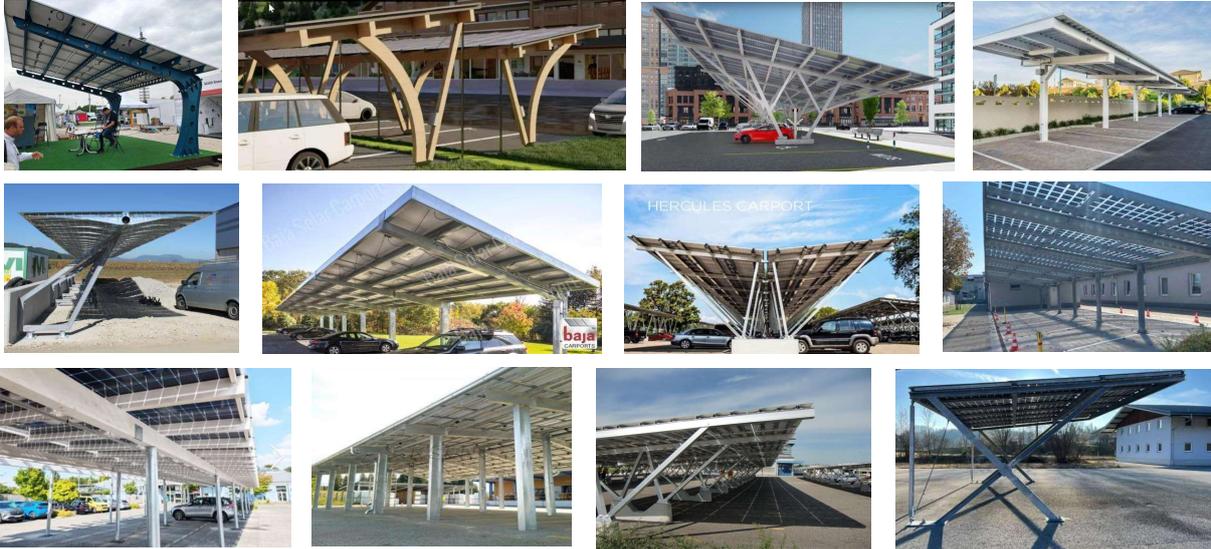
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Introduction

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PV carports ... there are many different systems



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- _ Engineering company in construction
- _ 700 employees
- _ 60 years of experience, e.g. in road construction, civil engineering, structural engineering, geotechnics, etc.
- _ 37 years of experience in PV planning

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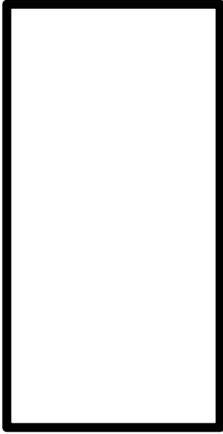
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Content

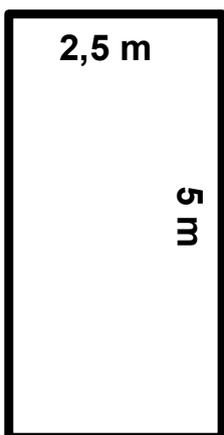
- Requirements: Standards
- Requirements: Loads and impacts
- Topologies
- Materials
- Foundations
- Planning

Requirements

Question: How large does a parking lot need to be?



Answer: It depends 😊



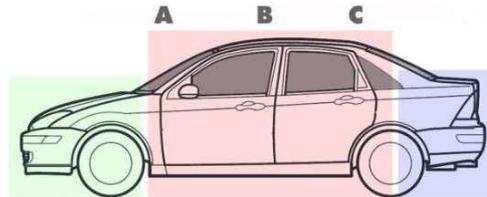
- Is it an official parking lot?
- If YES, it should be designed according to the applicable standards.
 - > The width of the driving aisle has an impact
 - > The arrangement of the columns has an impact
 - > The curbs have an impact

How does the VSS 40 291 standard help us?

– Turning radius



– Opening of car doors



– Head injuries



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Norm VSS 40 291

– The narrower the driving aisle, the wider the parking lot
-> for a 5 m driving aisle : parking lot width = 2.8 m

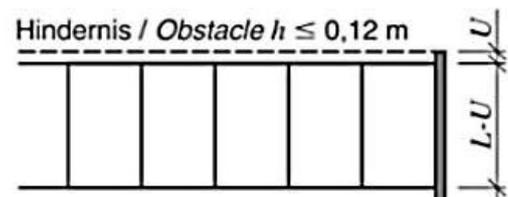
– Columns in unfavourable locations in the parking lot require wide parking lots

– Minimum clear height 2.3 m

– Reduction to 1.8 m possible at the front

– Signalisation of the height

– Certain ground obstacles in the parking bay, e.g. kerbs at the front, are possible

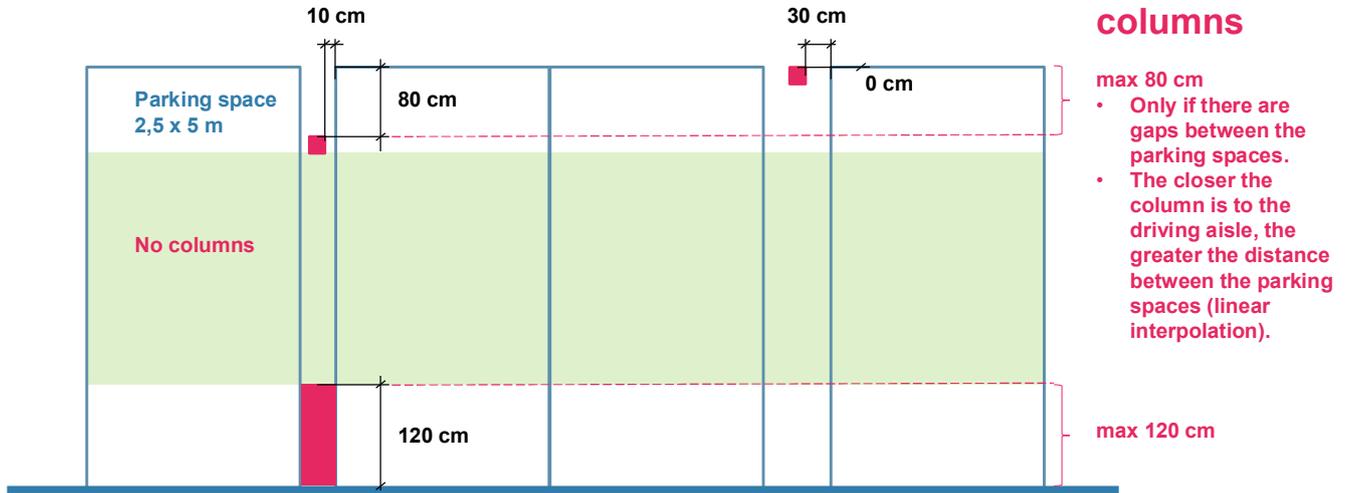


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Analysis of the standard (VSS 40 291)

Driving aisle



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Actions / Loads

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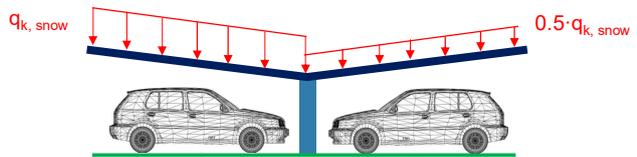
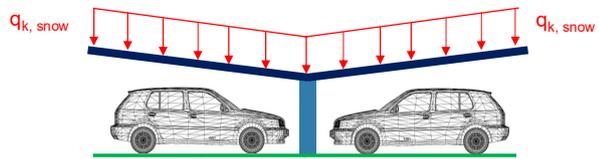
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Load actions – Snow example

- $q_{k, \text{snow}} = 1.4 \text{ kN/m}^2$
- SIA 261 does not consider eccentric snow load distribution on flat roofs.

-> Proposal by B&H:

- Eccentric load arrangement with 50% of the snow load on one side



Load actions – Wind (SIA 261) example

- Dynamic pressure: $q_0 = 0.8 \frac{\text{kN}}{\text{m}^2}$
- According to SIA 261: Load case wind with snow → no wind action in the z-direction
- Wind only: lower forces than snow load

→ For bending moment, the decisive load is snow.

Impact (according to SIA 261) for vehicles under 3.5 tonnes

- _ 60 kN impact on the structure
 - _ 0.6 m height above road surface
 - _ acting in the most unfavourable direction
- _ the structural safety must be ensured
- _ it can be calculated without a safety factor, as it is an extraordinary action

-> Weak point: bolt to the foundation

Overhead glazing SIA 2057

- _ Laminated safety glass
- _ OR if no laminated safety glass (PV modules):
 - _ Linear support of the glass is required
 - _ Residual load-bearing capacity of the glass must be verified (50% of the loads when both glasses are broken)
- _ OR sub-roof (e.g. trapezoidal sheet metal)

Electrical hazards (NIN)

- _ **Cables** on the underside should be laid in metal conduits to protect against damage (e.g. ski racks, ladders, metal rods, etc.) and thus prevent personal injury from electric shocks
- _ Rodent protection for the **cables**
- _ UV protection for the **cables**
- _ Possibly vandalism protection for **charging stations** and **inverter**

Drainage

- _ Water can drip off between the modules
- _ Drainage with downpipes into the central green strip
- _ Or drainage into the sewer system
 - _ via separate downpipes
 - _ via downpipes integrated into supports

Topology variants

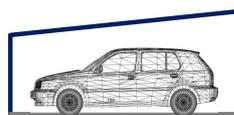
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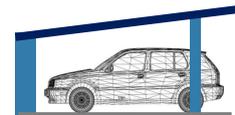
Topology variants

- **Single- vs. double-column system**
 - + Advantage: fewer obstacles when parking and opening doors
 - + Advantage: more comfortable entry and exit.
- **Double rows**
 - + Advantage: lower foundation costs
- **Bifacial modules**
 - + Advantage: up to 10% higher yield
 - + Advantage: more daylight (translucent)

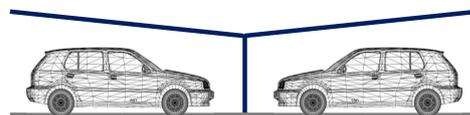
Single-column system



Double-column system



Double rows



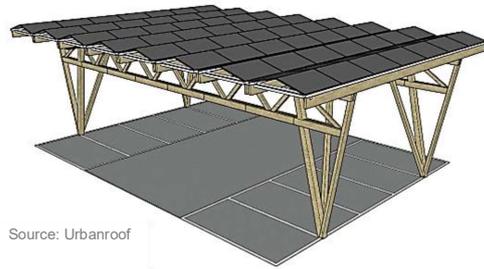
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Topology variants

Spanning over the driving aisle

- + Advantage: 30% more PV surface area
- + Advantage: similar benefits to the single-column system



Source: Urbanroof

PV suspended on cables

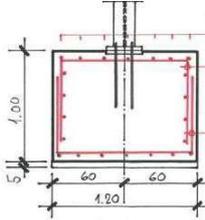
- + Advantage: no columns at all (maneuvering space for trucks)
- + Advantage: lightweight construction (lower embodied energy)



Source: DHP

Materials and foundations

Foundations



Strip foundation

In-situ concrete
(reinforcement approx.
120kg/m³, for example)

The classic solution

Slab foundation

In-situ concrete
(reinforcement approx.
200kg/m³, for example)

Above underground
garages

Micropile

Drill rod with
concrete injection

Can reach depths of
up to 7m, suitable
for challenging soil
conditions

Ground screw

Galvanized
according to soil
pH value

Performs well
under
compressive loads

Spinnanker

Threaded rods
screwed in

Performs well under
shear forces. Ideal
for tensioning
systems

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Source: Titan, Krinner, Spinnanker

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Foundations (KBOB) Exemplary

Type of foundation	Embodied energy kWh oil-eq/ 4 parking spaces	Greenhouse gas emissions kg CO2-eq/ 4 parking spaces
Concrete strip foundations	510	210
Concrete slab foundations	7'500	3'100
Micropile (2x)	440	120
Ground screw (2x)	580	170
Spinnanker (2x)	560	160

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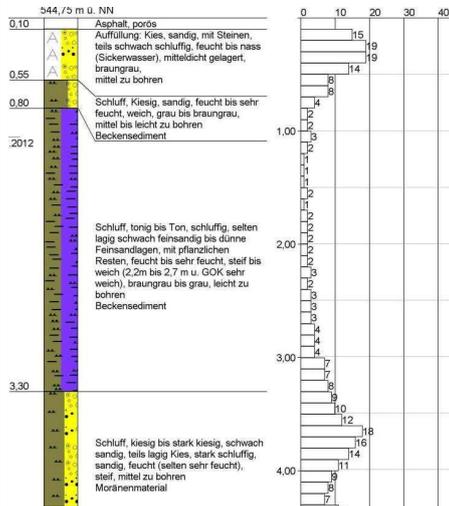
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Structure materials (KBOB)

Material	Embodied energy kWh oil-eq/kg	Greenhouse gas emissions kg CO2-eq/kg
Steel (galvanized)	3.3 – 3.5	0.73 – 0.78
Recycled steel (galvanized)	2.6 – 2.8	0.48 – 0.52
Raw blackened steel	3.3 – 3.5	0.73 – 0.78
Aluminum (recycled / new)	8.9 / 25.6	2.7 / 5.7
Solid wood (softwood or hardwood)	0.5 - 0.8	0.1 – 0.17
Laminated wood	1.2 – 1.6	0.25 - 0.34

Planning

Planning steps



1. Requirements analysis
2. Glare
3. Utility lines
4. Soil survey / Soil report
5. Slope / Gradient
6. Drainage
7. Building permit

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The following can be well combined with a PV carport:

- Lighting
- Parking occupancy signaling
- E-mobility charging stations
- Video surveillance

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Example Technische Betriebe Wil, SG



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- Strip foundations
- Racks: galvanized steel
- Water drainage: via separate downpipes

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Example Sauber Motorsport, Hinwil ZH



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- Foundation: Micropiles 5m
- Racks: Aluminum
- Water drainage: dripping between modules



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Thank you for your time

Basler & Hofmann, Zürich