

Anchoring a Cat Ladder to the Wall: Concrete vs AAC vs Cement Block — and How to Stop It Falling Off

Companion to the EN10025 Steel Grades Comparison workbook. Engineering principles for embedding fixed vertical ladders, with reference to BS EN ISO 14122-4, EN 1992-4, BS 8539, and SCDF storey-shelter design.

Why the wall connection is the most failure-prone part

A cat ladder almost never fails because the stile snapped or a rung sheared. **It fails because the wall fixings pulled out**, or because the wall itself crumbled around the anchor. Every forensic post-incident report on fallen access ladders points the same finger: **inadequate anchorage design or installation**.

This blog walks through:

1. The forces every wall fixing must resist
2. How concrete, AAC (autoclaved aerated concrete) and cement-block walls behave very differently as base materials
3. Which anchor systems suit each wall type
4. The practical detailing that prevents collapse — from drilling technique to stand-off design

1. The forces a cat-ladder anchor must resist

Per **BS EN ISO 14122-4:2016**, a typical 2-stile cat ladder transmits its loads to the wall through (usually) **four anchorage points**. The minimum design action at each anchor is:

Action	Magnitude per anchor	Direction
Tension (pull-out)	$\geq 3 \text{ kN}$ (two-stile) / $\geq 6 \text{ kN}$ (single-stile)	Perpendicular to wall
Shear	$\sim 1.5 \text{ kN}$	Parallel to wall (downward dead + climber)
Combined fall-arrest reaction	$\geq 6 \text{ kN}$ at top anchor when arrester deploys	Mostly tension

If the cat ladder in question is the **specific ladder inside a Civil Defence Storey Shelter** that provides access through the rescue hatch opening (and **only** that ladder — not roof-access or plant-deck cat ladders elsewhere on the building), then **SCDF Cl. 2.11.2** further requires **the mounting connection to the SS wall to withstand a shock load of $\geq 12.5 \text{ g}$ in all directions** (SCDF Cl. 2.11.2). For an 80 kg ladder, 12.5 g translates to a peak shock of **$\sim 10 \text{ kN}$ at every anchor in every direction**. **This 12.5 g check is narrowly scoped to the SS rescue-hatch ladder** — a roof-access or solar-PV cat ladder on the same building is governed by EN ISO 14122-4 (1.5 kN side load) and EN 1992-4, not by Cl. 2.11.2, and applying 12.5 g to those ladders would be over-design.

Design rule of thumb: size every anchor for **at least 7 kN tension + 2 kN shear** as a starting point, then verify with the manufacturer's design software (Hilti PROFIS, Fischer FiXperience, etc.) using the actual base material strength.

2. The three wall types — and why they behave so differently

The base material is the single biggest factor in anchor capacity. Designers in Singapore frequently encounter all three of the following in the same project:

(a) Reinforced concrete (cast in-situ or precast) — strength class C25/30 to C50/60

This is the **default base material** for which all branded anchors (Hilti, Fischer, Würth, etc.) are tested and certified. The European Technical Assessment (ETA) — the worldwide-recognised certification framework — requires anchor manufacturers to qualify their products in **cracked concrete C20/25** as the worst case ([ETA approved anchors](#)).

- Compressive strength: **20–60 MPa** depending on grade
- Density: $\sim 2,400 \text{ kg/m}^3$
- Anchor capacity (M12 chemical, 110 mm embedment): **typically 30–50 kN tension** in C25/30 cracked concrete
- Failure mode: usually steel yield of the rod itself before the concrete cone breaks out

(b) AAC — Autoclaved Aerated Concrete (Hebel, Ytong, Aercon)

Common in **Singapore HDB upgrading, partition walls, and shelter "storey-shelter" non-bearing walls** above the structural slab.

- Compressive strength: **typically 2.5–7.5 MPa** (about a tenth of normal concrete)
- Density: **400–700 kg/m³** (a quarter of concrete)
- Behaviour: porous, friable, no aggregate
- Anchor capacity (typical chemical anchor, AAC-rated, M10): **2–4 kN** — an order of magnitude lower than RC
- Critical issue: **standard concrete anchors will not work** — they spin, crush the cells, and pull out at low load
- Special anchors required: **AAC-specific chemical fixings** like [Fischer FIS V Plus / FUR](#) used with sleeve mesh, or Hilti **HUS-AAC / HRD-K** screws

Critical takeaway: An ETA "Option 1" approval for cracked concrete tells you **nothing** about AAC performance. You must use anchors carrying a separate aBG/ETA approval **explicitly for autoclaved aerated concrete**.

(c) Cement / hollow concrete block masonry (CMU)

- Compressive strength: **5–20 MPa** for the unit, but $\approx 4\text{--}10 \text{ MPa}$ for the assembled wall
- Two sub-types:
 - **Solid block** — anchors behave roughly like weak concrete
 - **Hollow block** — anchors must engage the **face shell** or use a **sleeve / through-fixing** that bridges the void
- Anchor capacity (M12 sleeve anchor in solid cement block, 80 mm embed): **typically 4–8 kN tension**
- For hollow block: **always use a chemical anchor with a perforated mesh sleeve** (Fischer FIS H, Hilti HIT-SC); resin cures inside and around the cavity instead of dribbling away

3. Choosing the right anchor for each wall type

The anchor families fall into four engineering categories. Each has a sweet spot.

Anchor family	Best base material	How it works	Typical Singapore use for cat ladders
Cast-in / through bolt	New concrete	Bolt cast into formwork or post-fixed through wall with backing plate	Best practice for safety-critical anchorages — bypasses anchor design altogether
Mechanical expansion (wedge / sleeve)	Solid concrete only	Tightening pulls a cone, expanding sleeve against drilled hole	Hilti HST3, KB-TZ2; Fischer FAZ II — fast, simple, but never in AAC or near edges
Undercut anchor	Cracked concrete, seismic	Drill a controlled undercut in the hole; anchor fills the undercut for positive lock	Hilti HDA, Fischer Zykon — premium; for SCDF shelters and seismic
Chemical / adhesive (epoxy or vinylester)	Concrete, masonry, AAC (with sleeve)	Two-component resin injected into hole; threaded rod pushed in; cures in 30–90 min	Hilti HIT-RE 500 V4, Fischer FIS EM Plus / FIS V Plus — gold standard for retrofit cat ladders

Recommended anchor selection by wall type

Wall	Recommended anchor	Why
RC concrete, exterior	Chemical anchor (HIT-RE 500 V4 or FIS EM Plus) + SS316 threaded rod M12, 110 mm embedment	ETA Option 1 for cracked concrete + corrosion immunity for outdoor use
RC concrete, interior dry	Mechanical wedge anchor M12 (Hilti HST3 or Fischer FAZ II)	Cheaper, faster, ETA-approved for cracked concrete
RC, SS wall — SCDF Storey Shelter rescue-hatch ladder ONLY (Cl. 2.11.2)	Undercut anchor or HIT-RE 500 + seismic-rated rod, ETA C2	Required to satisfy 12.5 g shock + seismic action; does not apply to roof-access or solar-PV ladders
AAC (Hebel/Ytong)	Chemical anchor with mesh sleeve, AAC-specific rating (e.g. Fischer FIS V Plus + FIS H sleeve)	Standard concrete anchors will crush the AAC cells
Solid cement block	Chemical anchor + sleeve, M10 minimum, 100 mm embed	Block compressive strength too low for expansion anchors
Hollow cement block	Chemical anchor + perforated mesh sleeve (mandatory)	Stops resin running out into the void
Brick or random masonry	Chemical anchor + mesh sleeve, derate capacity by 50%	Highly variable substrate; always pull-test on site

4. Why the wall sometimes wins — anchor pull-out failure modes

When a cat ladder rips off a wall, the failure usually traces to one of these causes:

Failure mode A — Concrete cone breakout (in concrete)

The anchor rod stays bonded to the resin, but a cone of concrete shaped like a **45° pyramid above the rod** lifts out. This happens when:

- **Embedment depth too shallow** — rule of thumb: chemical anchor embedment $\geq 8 \times$ bolt diameter (e.g. M12 ≥ 96 mm; engineers usually round to 110 mm)
- **Anchor too close to an edge** — minimum edge distance in cracked concrete = embedment depth (so 110 mm clear from any edge for M12 at 110 mm embed)
- **Anchor in a pre-existing crack** — wide cracks (> 0.5 mm) reduce capacity; only "cracked concrete" rated anchors (Option 1 ETA) tolerate this

Failure mode B — Adhesive bond failure (in chemical anchors)

The rod pulls out cleanly with no concrete attached. Caused by:

- **Hole not cleaned** — by far the most common cause. EN 1992-4 and every ETA require: **brush, blow, brush, blow** before injecting resin. Dust film between resin and concrete halves capacity instantly.
- **Wrong resin temperature** — most epoxies need $\geq +5$ °C base material; vinylester tolerates -10 °C
- **Curing too short** — fully loaded before cure time elapsed (HIT-RE 500 V4 needs 7 hr at 20 °C, longer when cooler)
- **Resin past expiry** — expired cartridges cure incompletely

Failure mode C — Substrate crushing (in AAC and weak block)

The block fails before the anchor does. The hole enlarges under load and the rod pivots. Signs:

- White powdery residue around the anchor head
- Visible enlargement of the drilled hole
- Anchor capacity often well below the published "concrete" value

Solution: use AAC-rated chemical anchors with mesh sleeves, increase embedment to 150 mm minimum, and **always pull-test** per BS 8539 (1-in-40 at 1.5× design, or 1-in-25 at 1.25×).

Failure mode D — Corrosion-induced failure

Especially for galvanised steel rods in coastal Singapore environments:

- Galv coating breached in the hole (drill scrapes it off)
- Chloride-laden moisture wicks down the rod-resin interface
- Rod necks at the wall face, snaps under shear
- Failure often 5–10 years after install with no warning signs

Solution: **A4 stainless (SS316) threaded rods** for any external or coastal cat ladder anchorage. Cost premium ~30% over A2 (SS304), but service life triples.

5. Engineering details that prevent collapse

These are the practical detailing items every cat-ladder installation drawing should include:

(a) Stand-off bracket geometry

EN 14122-4 requires **at least 200 mm clear behind the rung centreline** to a wall. This means the **bracket projects 200 mm minimum from the wall surface**. Bracket should be:

- Triangulated (gusseted), not just a flat plate — eliminates levered tension on the top anchor
- Welded or bolted to a backing plate ≥ 6 mm thick spanning **two anchors per bracket** — distributes load
- Fitted with a **spherical washer** or DIN 6916 hardened washer to allow rod alignment errors

(b) Anchor pattern — the "two-anchor-per-bracket" rule

A single anchor per bracket is a **disaster waiting to happen** — any small misalignment becomes a lever amplifying the tension to 3× the calculated value. Every cat-ladder bracket should have:

- **At least 2 anchors vertically separated** by 100–150 mm
- **Top anchor** takes the lever-arm tension (governs design)
- **Bottom anchor** acts as the pivot in shear

For the SCDF Storey Shelter rescue-hatch cat ladder specifically (12.5 g shock per Cl. 2.11.2 — not applicable to other cat ladders on the same project), use **4 anchors per bracket** in a square pattern.

(c) Edge distance and spacing

Per ETA design rules (EN 1992-4):

- Minimum **edge distance** $c_1 \geq 1.0 \times \text{hef}$ (embedment depth) — for M12 at 110 mm embed = 110 mm from edge
- Minimum **spacing** $s \geq 2.0 \times \text{hef}$ between anchors — = 220 mm
- If edge or spacing is reduced, **capacity is derated** by software — never ignore the warnings

(d) Drilling, cleaning, injection

Most failures are install errors, not design errors. The non-negotiable sequence for chemical anchors:

1. **Drill** with the correct bit diameter (often +2 mm of rod for chemical, exactly bolt diameter for mechanical)
2. **Brush** with a steel-bristle brush, 4 strokes minimum
3. **Blow out** with oil-free compressed air or hand pump, until dust ceases
4. **Brush again**, then **blow again** — twice each (the "2× brush, 2× blow" rule of EN 1992-4)
5. **Inject** resin from the bottom up, withdrawing the nozzle as the hole fills, to prevent air pockets
6. **Insert** rod with a slow rotation to displace air
7. **Hold or support** rod for the gel time (10–20 min)
8. **Wait** the full cure time before any load — Hilti HIT-RE 500 V4 = **7 hr at 20 °C**

(e) Site testing

Per **BS 8539:2012 Code of Practice for post-installed anchors in concrete and masonry**, every safety-critical anchorage (life-safety = always for cat ladders) must be proof-load tested. The standard's sampling regime gives the engineer two options:

- **1-in-40 anchors at 1.5× the design action** (the usual choice for life-safety fixings), **or**
- **1-in-25 anchors at 1.25× the design action** (denser sampling, lower load).

Load held for **60 seconds** with no measurable slip. For a small ladder with fewer than 40 fixings, at least one anchor per discrete bracket type must be tested at the 1.5× rate. The proof load is **1.5× the design tension at the actual anchor location** — which for a top bracket carrying a fall-arrest reaction is much higher than the ≥ 3 kN code-prescribed minimum. Document with a signed test sheet — this is what the LEW or PE will sign off.

(f) Inspection and re-tightening

- Initial inspection 6 months post-install (catch installation errors)
- Annual visual: rust, missing nuts, cracks in render around anchor
- 5-year proof-load re-test of one anchor per ladder for marine / outdoor installations

6. Worked detail — a typical compliant cat ladder fixing

For a **4 m ladder fixed to a C30/37 reinforced concrete wall, exterior, coastal Singapore**:

Element	Spec
Stiles	SS304 50×10 mm flat, BS EN 10088-2 grade 1.4301
Bracket	SS304 angle 50×50×6, gusseted, 200 mm projection, 100×8 mm backing plate
Anchor system	Hilti HIT-RE 500 V4 epoxy with A4 (SS316) threaded rod M12 × 160 mm , hef = 110 mm
Anchors per bracket	2 (vertically separated 120 mm)
Edge distance	150 mm minimum from any concrete edge
Drilling	Ø 14 mm hammer drill, hef = 110 mm
Cleaning	2× steel brush, 2× compressed-air blow
Resin cure	7 hr at +20 °C ambient before any load
Site test	1.5 × 3 kN = 4.5 kN proof load on 3 random anchors per ladder, 60 s hold
Inspection	6-month, then annual visual; 5-year proof retest

Indicative cost for a complete 4-bracket (8-anchor) installation in materials only: **S\$ 80–120** of HIT-RE 500 V4 resin (one 500 ml cartridge ≈ S\$ 73 trade price per [Hilti SG](#)) plus **S\$ 60** of SS316 threaded rod.

7. The collapse-mitigation checklist

To boil all of the above into one page that goes into the project quality plan:

#	Mitigation	Why
1	Confirm wall type & strength before specifying anchor (core sample if uncertain)	Wrong substrate = wrong anchor = pull-out
2	Use ETA Option 1 / cracked-concrete-rated anchors only	Walls always crack near anchors over time
3	Always 2 anchors per bracket minimum (4 for shelters)	Eliminates lever-arm overload
4	Embedment ≥ 8d (e.g. ≥ 96 mm for M12)	Concrete cone capacity scales with hef ²
5	Edge distance ≥ hef	Edge effects halve capacity if violated
6	A4 stainless (SS316) rods for outdoor / coastal	Galv rusts through in 5–10 years
7	Strict 2× brush + 2× blow hole cleaning	Dust film halves bond strength
8	Full cure time before any load	Half-cured epoxy has 30% rated strength
9	Pull-test per BS 8539 (1-in-40 at 1.5× design, or 1-in-25 at 1.25×)	Catches install errors before a fall does
10	Annual visual inspection + 5-year re-test	Tropical climate accelerates corrosion
11	Use manufacturer design software (Hilti PROFIS / Fischer FiXperience) for the final capacity check	Captures edge, spacing, group effects automatically
12	For AAC walls — only use AAC-specific anchors with mesh sleeves; never expansion anchors	AAC cells crush under expansion load

8. Bottom line

A cat ladder is only as safe as its weakest anchor. The structural strength of the ladder material — covered in the previous blog — only matters if the wall connection holds. The hierarchy of importance is:

1. **Substrate** — RC concrete is the easy case; **AAC and hollow block need specialist anchors and detailing.**
2. **Anchor system** — chemical anchors (Hilti HIT-RE 500 V4, Fischer FIS EM Plus) dominate retrofit work because they handle cracked concrete and offer ETA-rated capacities up to M30. Mechanical anchors are cheaper but unforgiving in poor substrates.
3. **Detailing** — two-anchor brackets, generous edge distance, SS316 rods, gusseted brackets — all of these prevent failures the calculation never predicted.
4. **Workmanship** — 80% of pull-out failures are install errors. Cleaning and cure time are non-negotiable.
5. **Verification** — site pull-tests per BS 8539. Without them, the design exists only on paper.

Spec the right anchor, in the right wall, installed the right way, and verify with a test. Skip any one of those four, and the ladder will eventually find the weakest link.

References cited inline. The next blog in this series compares Hilti and Fischer anchor systems against generic / unbranded alternatives, with pricing and risk analysis.