

# Designing an 18-Metre Cat Ladder: What Goes Into a QP-Endorsed Vertical Access Solution

Drawing on real-world design drawings and QP design reports for industrial cat ladders in Singapore (Aggreko 8B Buroh Street project), this blog walks through the engineering decisions that go into specifying, calculating, drawing and endorsing an 18 m fixed vertical ladder.

## Why 18 metres is a watershed height

A cat ladder of 3–6 m is essentially a maintenance prop: easy to specify, easy to install, easy to certify. At **18 m total climb**, the design problem multiplies in three directions simultaneously:

1. **Climber fatigue and fall-arrest physics** — a single uninterrupted vertical climb beyond ~6 m is unsafe even for fit users. EN ISO 14122-4 and OSHA both demand staged climbs with rest landings.
2. **Buckling and dynamic deflection** — a slender 18 m steel column wants to whip laterally. Stiffness, not strength, drives stipe sizing.
3. **Anchorage demand** — 18 m of self-weight + climber + wind load + fall-arrest reaction transmits into wall fixings that must each take 5–10 kN repeatedly over a 25-year life.

The reference project for this blog is the **Aggreko / 8B Buroh Street** cat ladder — designed by **DWB CS-Engineering Consultants**, fabricated in **Aluminium AA 6063-T6**, with a middle landing platform, full safety cage, and chemical-anchor wall fixings. The QP report runs **133 pages** of STAAD.Pro analysis to clear a single ~8.6 m ladder for endorsement under the Singapore Building Control Act. Scaling that thinking to 18 m is what this blog is about.

## 1. Anatomy of an 18 m cat ladder

An 18 m cat ladder is **never one continuous run**. It is a stack of three 6 m flights (or two 9 m flights with a single mid-rest), separated by **rest platforms / landing platforms**. A typical layout:



**Why staggered flights?** EN ISO 14122-4 §4.4.2.2 requires that if a climber falls, the **fall is intercepted at the rest platform within  $\leq 6$  m** — a continuous straight 18 m drop is not survivable even with a fall arrester. Modern designs offset adjacent flights laterally by  $\geq 300$  mm so that a fall ends on the platform edge, not the rung below.

**Standard component sizes** (taken directly from the Buroh Street drawings, scaled):

Element	Specification used	Reference
Stile / stringer	<b>70 × 30 × 3 mm aluminium C-channel</b> (AA 6063-T6)	DWB CS-Engineering report
Rung	<b>30 × 5 mm aluminium flat bar</b> (or 25 × 25 × 3 mm SHS) — flat tread ≥ 20 mm wide, non-slip top	EN ISO 14122-4 §5.2.2.4 requires flat tread ≥ 20 mm. <b>Round bar is non-compliant</b> — slips off the foot under wet conditions.
Rung pitch	<b>300 mm constant</b>	EN 14122-4 §5.2.2.2 (225–300 mm)
Cage hoop	<b>75 × 6 mm aluminium flat bar horizontal</b> , 50 × 6 mm vertical	OSHA / EN cage geometry
Wall bracket	<b>75 × 75 × 6 mm hollow section</b> + 75 × 50 × 3 mm gusseted bracket support	Buroh St drawings
Bearing plate	<b>210 × 210 × 10 mm</b> (mid-rest), <b>200 × 200 × 10 mm</b> (intermediate), <b>100 × 150 × 10 mm</b> (single-anchor)	Buroh St drawings
Anchors	<b>4 × Hilti HST3-R M12 / Hilti HIT-RE 500 V4 with M12 rod, embedment ≥ 110 mm</b>	EN 1992-4 + Hilti ETA
Bolts/nuts	<b>Stainless A4 / SS304 M8–M16</b>	Drawing notes
Roof clamp	<b>Aluminium 6005-T5</b> (Aggreko design)	Drawing notes

## 2. The design loads to satisfy

For an 18 m ladder serving an industrial roof in Singapore, the QP must run loads from **four codes simultaneously**:

Load	Source	Magnitude
Self-weight (dead)	EC0 / SS EN 1990	78.5 kN/m <sup>3</sup> steel · 27 kN/m <sup>3</sup> aluminium
Climber rung load <b>F1</b>	EN ISO 14122-4 §5.1	<b>1.5 kN per rung</b> , 100 mm wide footprint, anywhere
Climber stile load <b>F2</b>	EN ISO 14122-4 §5.1	<b>1.5 kN per stile</b> , two locations 2 m apart
Platform live load	EC1 / SS EN 1991-1-1	<b>1.5 kN/m<sup>2</sup></b> + concentrated <b>1.5 kN per person</b>
Wind load	SS EN 1991-1-4 + NA Singapore	<b>0.80 kN/m<sup>2</sup></b> (Buroh St report value)
Fall-arrester reaction	EN ISO 14122-4 §5.7	≥ <b>6 kN</b> at top anchor
SCDF storey-shelter shock (SS rescue-hatch ladder ONLY)	SCDF Cl. 2.11.2	<b>12.5 g in all directions</b> — applies <b>only</b> to a cat ladder fixed to the SS wall inside a Civil Defence Storey Shelter providing access through the rescue hatch; <b>not</b> to roof-access or solar-PV cat ladders

These are **characteristic loads**. The QP applies partial factors per EC0:

- $\gamma_G = 1.35$  for permanent (dead)
- $\gamma_Q = 1.50$  for variable (climber, wind)

- $\gamma_{M0} = 1.00$  for carbon-steel cross-section resistance (EN 1993-1-1);  **$\gamma_{M0} = 1.10$  for stainless cross-section** (EN 1993-1-4);  **$\gamma_{M0} = 1.10$  for aluminium cross-section** (EN 1999-1-1);  $\gamma_{M1} = 1.10$  for member buckling. The 1.10 factor reflects manufacturing variability and local-buckling sensitivity — not, as is sometimes informally said, the lower elastic modulus.

The Buroh Street report explicitly cites:

"EC0 – Eurocode 0 SS EN 1990 & NA – Basis of Structural design; EC1 – SS EN 1991-1-1 & NA; EC3 – SS EN 1993-1-1 & NA"

For an 18 m ladder this is the **non-negotiable code stack**.

### 3. The structural model — what an 18 m STAAD.Pro run looks like

The Buroh St QP modelled an **8.6 m** ladder in STAAD.Pro V8i with:

- **205 nodes**
- **~200 frame elements** (one per rung + stiles + cage hoops + brackets)
- **Multiple load cases** combined per EC0 fundamental combination

Scaled to **18 m**, you would expect:

- **~430 nodes**
- **~430 elements**
- **2 staggered rest platforms** modelled as horizontal frames
- **8–12 wall-anchor points** (4 per platform + 4 per top/bottom)

#### Critical model details

##### (a) Boundary conditions

- Wall brackets are modelled as **fixed in 3 translations, free in 3 rotations** (pinned to the wall plate). Some QPs model them as fully fixed (rigid moment connection) — this overestimates capacity. The Buroh St report uses **pin-fixed** which is the conservative and correct approach.

##### (b) Stile-rung joints

- All rungs are welded (3 mm fillet weld all round, per general note 6 of the drawings). Modelled as **rigid** in the frame analysis.

##### (c) Cage as a structural element?

- Most QPs **exclude the cage from primary structural action** — it is treated as fall-arrest hardware only, and the stiles must take 100% of the climber load. This is the safe assumption.

##### (d) Buckling

- For aluminium stiles 6 m long, slenderness  $\lambda = L/i \approx 6000 / 11 \approx 545$ , which is far above the EC9 limit ( $\lambda_{max} = 200$  for compression members). **Lateral restraint at every rung** is what makes the assumption work — the rung-to-stile welds force buckling to occur over a 300 mm rung pitch, not 6 m.

### 4. Worked utilisation check on the stile

Using the Buroh Street section (70 × 30 × 3 mm aluminium C-channel, AA 6063-T6,  $f_y = 190 \text{ N/mm}^2$ ) over a 300 mm rung-to-rung span:

**Section properties** (C-channel 70 × 30 × 3):

- Area  $A = 270 \text{ mm}^2$
- $I$  (strong axis) =  $8.6 \text{ cm}^4 \approx 86,000 \text{ mm}^4$
- $W_{el}$  (strong axis) =  $2.46 \text{ cm}^3 = 2,460 \text{ mm}^3$

**Design moment from  $F_1 = 1.5 \text{ kN}$  at mid-rung (treating stile as continuous beam):**

$$M_{Ed} = (F_1 \cdot L) / (8) = (1.5 \cdot 0.300) / (8) = 0.056 \text{ kN}\cdot\text{m} = 56 \text{ N}\cdot\text{m}$$

**Design bending resistance ( $\gamma_{M1} = 1.10$  for aluminium):**

$$M_{Rd} = (f_y \cdot W_{el}) / (\gamma_{M1}) = \frac{190 \cdot 2,460}{1.10} = 425 \text{ N}\cdot\text{m}$$

**Utilisation:**  $M_{Ed} / M_{Rd} = 56 / 425 = 13\% \checkmark$  — comfortable for the rung-to-rung span.

Now check the **stile between brackets** — 1,500 mm bracket spacing,  $F_2 = 1.5 \text{ kN}$  at mid-span:

$$M_{Ed} = (F_2 \cdot L) / (4) = (1.5 \cdot 1.500) / (4) = 0.563 \text{ kN}\cdot\text{m} = 563 \text{ N}\cdot\text{m}$$

**Utilisation:**  $563 / 425 = 132\% \times$  — **fails** if no intermediate restraint.

That is exactly why the 18 m design needs **brackets at  $\leq 1.5 \text{ m}$  spacing**, and ideally  **$\leq 1.0 \text{ m}$  for aluminium** (because of the lower modulus  $E = 69 \text{ GPa}$  vs  $210 \text{ GPa}$  for steel). A "skinny" aluminium ladder with sparse brackets is **the most common QP rejection reason** in Singapore submissions.

The Aggreko drawing addresses this by specifying brackets at **1.45 m, 1.50 m intervals** — and that drawing is for a **5 m ladder**. For 18 m the bracket pitch would need to drop further or the stile section sized up to  $70 \times 30 \times 4 \text{ mm}$  or even a **closed SHS  $50 \times 50 \times 4 \text{ mm}$**  for the longest spans.

---

## 5. The wall connection — the highest-failure subsystem

Every cat-ladder forensic report points to the same conclusion: **the wall fixings are the failure-prone subsystem**, not the ladder itself. The Buroh Street commenting reviewer flagged exactly this — visible on Sheet 5 of the COMMENTS PDF:

- **"BOLT (M16) DIAMETER NOT MENTIONED"** — drawing didn't specify the rod diameter for the chemical anchor
- **"EMBEDMENT 85 mm"** — flagged as inadequate for M16 chemical anchor (rule of thumb is  $8d = 128 \text{ mm}$  for M16)
- **"NOT TALLY"** — bracket detail and assembly view didn't match
- **"SUPPORT MISSING"** — the warehouse front elevation showed an unsupported run
- **"NOT TALLY PLS UPDATE"** — section dimensions inconsistent across sheets

These are **the five most common reviewer comments** on cat-ladder submissions in Singapore, and at 18 m every one of them becomes a structural defect rather than a paperwork fix.

### Anchor design for an 18 m ladder

A representative bracket on an 18 m ladder might carry:

Action	Value
Climber tension via lever arm (200 mm projection)	$1.5 \text{ kN} \times 200/120 = \mathbf{2.5 \text{ kN}}$
Self-weight share of one stile	0.4 kN
Wind on one bracket area	$0.8 \text{ kN/m}^2 \times 0.5 \text{ m}^2 = \mathbf{0.4 \text{ kN}}$
Fall-arrester impact (top bracket only, factored)	<b>6 kN</b> characteristic $\rightarrow$ <b>9 kN</b> design
<b>Total tension at top bracket (factored)</b>	$\approx \mathbf{12 \text{ kN}}$

For a **Hilti HIT-RE 500 V4 + M12 stainless threaded rod** in C25/30 cracked concrete with hef = 110 mm and edge distance c1 = 150 mm, the ETA-tabulated tension capacity is approximately **15–20 kN** — comfortable. But drop to **M10 with hef = 80 mm** (the embedment shown on the Buroh St drawing) and capacity falls to roughly **6–8 kN** — failing the top-bracket case.

This is precisely why the reviewer flagged the 85 mm embedment. **For 18 m ladders the rule is: M12 minimum rod, hef  $\geq$  110 mm, ETA Option 1 cracked-concrete approval, A4 stainless rod for outdoor.**

## 6. The middle landing platform — design specifics

The Buroh St ladder includes a single **middle landing platform**, configured as a 740 mm  $\varnothing$  circular platform inside the safety cage. Detail callouts include:

- **75 × 75 × 6 mm SHS** as primary platform frame
- **38 × 38 × 6 mm angle bar** as in-fill
- **50 × 75 × 3 mm hollow section** as platform support to the wall
- **6 mm thick galvanised mesh wire** as tread / fall-through protection
- Hand-grabs continuing through the platform per EN 14122-4 §5.6

For an 18 m ladder you need **at least two such platforms** (one every 6 m or every 12 m if a fall arrester is fitted, per EN 14122-4 §4.4.2.4):

Climbing height	Required platforms
$H \leq 6 \text{ m}$	None (single flight)
$6 \text{ m} < H \leq 12 \text{ m}$	One platform
$12 \text{ m} < H \leq 18 \text{ m}$	<b>Two platforms</b>
$H > 18 \text{ m}$	Three or more

### Design loads for each platform:

- 1.5 kN/m<sup>2</sup> distributed (EC1) — standard floor live load
- 1.5 kN concentrated per person at the unfavourable corner
- Same fall-arrester reaction at the upper-flight start anchor

## 7. Geometry, clearances and OSHA-compatible layout

Per EN ISO 14122-4 (most-cited values for a Singapore submission):

Parameter	Value	Clause
Rung pitch (constant)	225–300 mm	§5.2.2.2
Tread surface flat width	≥ 20 mm	§5.2.2.4
Clear width between stile and slip-protection	150–250 mm	§5.2.2.3
Clearance in front of rung	≥ 650 mm (≥ 600 mm at obstacles)	§4.4.1
Clearance behind rung	≥ 200 mm (≥ 150 mm at obstacles)	§4.4.1
Cage from rung centreline	700–800 mm	§5.5
Cage hoop pitch	≤ 1500 mm	§5.5
Top-rung exit gap	60–75 mm to landing	§4.5
Fall-arrester required from	≥ 3 m climbing height	§4.4.2.2
Single-flight max length	6 m	§4.4.2.3
Rest platform interval (with arrester)	≤ 12 m	§4.4.2.4

The Aggreko drawing dimensions (1450 mm cage projection, 750 mm cage standoff, 5000 mm flight, 450 mm exit width) all sit safely inside these envelopes.

## 8. The QP submission package — what 18 m takes

A submission to BCA/SCDF for an 18 m cat ladder under Section 5A of the Building Control Act typically includes:

1. **Architectural drawings** — front elevation, side elevation, plan, all with key dimensions
2. **Structural drawings** — bracket details, weld details, anchor bolt schedule, bearing plate sizes
3. **Material schedule** — every bar size, grade, finish, fastener spec
4. **Design report** — typically 80–150 pages:
  - Introduction & code references
  - Design loadings (dead, live, wind, climber, arrester)
  - Material strengths
  - **STAAD.Pro 3D model output** (geometry, load cases, member forces, deflections)
  - **Stile bending check** at most onerous span
  - **Bracket utilisation check** (welded connection capacity)
  - **Anchor design** per EN 1992-4 / Hilti PROFIS / Fischer FiXperience output
  - **Deflection check** — typically L/200 for industrial access ladders
  - **Wind / dynamic check** if H > 12 m
5. **PE endorsement** — name, registration number, signature, date, declaration that the design complies with the Building Control Act
6. **Site test results** — anchor proof-load tests at 1.5 × design tension per BS 8539, signed test sheets

The Buroh Street files in workspace illustrate this exactly: a separate **133-page warehouse design report** ( [20260225-QP-REPORT-FOR-CAT-LADDER-WAREHOUSE-For-Buroh-Street-ENDORSED.pdf](#) ) plus a **drawing set with a reviewer's mark-up PDF** ( [20260223-Buroh-St-Cat-ladder-COMMENTS.pdf](#) ) — and at this scale the workflow is **draw → STAAD model → calc report → PE endorse → reviewer comments → revise → re-endorse → BCA submission**.

## 9. Common failure modes the QP must catch

#	Failure mode	Mitigation
1	<b>Stile buckling between widely-spaced brackets</b>	Bracket pitch $\leq 1.5$ m for steel, $\leq 1.0$ m for aluminium
2	<b>Anchor pull-out from inadequate embedment</b>	hef $\geq 8d$ (e.g. 96 mm for M12); use ETA Option 1 cracked-concrete chemical anchor
3	<b>Galvanic corrosion at aluminium-steel anchor interface</b>	Stainless A4 fasteners only; isolating washer if mixed
4	<b>Single-anchor bracket levering off</b>	Always 4 anchors per bearing plate (Buroh St drawings already show this)
5	<b>Cage gap in fall-fall-through plane</b>	Cage hoop spacing $\leq 1500$ mm; vertical strap pitch $\leq 300$ mm
6	<b>Wind-induced fatigue</b> (especially $> 12$ m)	Add diagonal wall-tie struts; check EC1 wind dynamic factor
7	<b>Inadequate rest platform spacing</b>	Max 6 m unprotected; 12 m with arrester
8	<b>Drawing/calculation mismatch</b>	"NOT TALLY" reviewer flag — formal QA check before submission
9	<b>Insufficient bracket gusseting</b>	75 $\times$ 50 $\times$ 3 mm minimum for outdoor stainless / aluminium
10	<b>Top-rung exit detail unclear</b>	EN 14122-4 §4.5 transition barrier or hand-grab extension explicit on drawing

## 10. The 18 m design checklist

Boil down everything above into a one-page QC sheet that goes into the project file alongside the QP report:

<input type="checkbox"/>	Item	Reference
<input type="checkbox"/>	Total climbing height $\leq 18$ m to a rest platform / discharge level	EN 14122-4 §4.4.2
<input type="checkbox"/>	Two staggered rest platforms at $\leq 6$ m intervals (or $\leq 12$ m with arrester)	EN 14122-4 §4.4.2.4
<input type="checkbox"/>	Rung pitch 300 mm constant; rung $\varnothing \geq 25$ mm or flat $\geq 20$ mm; non-slip top	EN 14122-4 §5.2.2
<input type="checkbox"/>	Cage required (climbing height $> 3$ m); hoop spacing $\leq 1500$ mm	EN 14122-4 §5.5
<input type="checkbox"/>	Stile section sized for 1.5 kN at mid-bracket span; deflection $\leq L/200$	EC0 / EC9
<input type="checkbox"/>	Bracket pitch $\leq 1.5$ m steel; $\leq 1.0$ m aluminium	Engineering judgment
<input type="checkbox"/>	Anchor: ETA Option 1 chemical, M12 minimum, hef $\geq 110$ mm, A4 stainless rod	EN 1992-4
<input type="checkbox"/>	4 anchors per bearing plate; min edge distance $c_1 \geq hef$	EN 1992-4
<input type="checkbox"/>	Top bracket sized for 6 kN fall-arrester reaction (factored 9 kN)	EN 14122-4 §5.7
<input type="checkbox"/>	Wind load 0.80 kN/m <sup>2</sup> applied to cage projected area	SS EN 1991-1-4
<input type="checkbox"/>	All welds 3 mm fillet all round; aluminium use 4043/5356 filler	AWS D1.2
<input type="checkbox"/>	All fastener and stile materials cross-checked between drawing and report	"NOT TALLY" prevention
<input type="checkbox"/>	STAAD/SAP/RFEM model output included in QP report	BCA submission requirement
<input type="checkbox"/>	PE endorsement page signed and stamped	Building Control Act §5A
<input type="checkbox"/>	On-site anchor pull-test 1.5 $\times$ design tension per BS 8539	Quality verification

## 11. Bottom line

An 18 m cat ladder is not a bigger version of a 5 m ladder. It is a **structural system** with two rest platforms, full fall-arrest, staggered flights, twelve-plus wall anchors, and a calculated dynamic envelope that no single rule of thumb covers. The Buroh Street project files in this workspace — drawings, comments and 133-page QP report — show every one of those moving parts in a real-world Singapore submission.

The four levers that determine whether an 18 m design **succeeds or fails reviewer comment** are:

1. **Structural geometry** — bracket pitch tight enough for the chosen stile material's modulus; rest platforms at  $\leq 6$  m /  $\leq 12$  m (with arrester); cage hoops  $\leq 1.5$  m.
2. **Material grade** — aluminium 6063-T6  $f_y = 190$  N/mm<sup>2</sup> **or** 6061-T6  $f_y = 240$  N/mm<sup>2</sup>; SS304  $f_y = 210$  N/mm<sup>2</sup>; galvanised S275 carbon steel where service environment permits. **Match the section size to the modulus, not just the yield.**
3. **Anchor system** — ETA Option 1 chemical anchor,  $\geq$  M12, hef  $\geq$  110 mm, A4 stainless rod, 4 anchors per plate. The most-cited reviewer comment is anchor underspec.
4. **Drawing-to-report consistency** — every dimension, grade, fastener spec, embedment depth and bracket detail must match exactly across the drawing set and the calculation report. "NOT TALLY" is the easiest-to-avoid rejection reason.

Get those four right, and the PE endorsement is a formality. Get any one wrong, and the submission bounces — usually with red ink on the bracket detail.

---

References inline. Project files in workspace: 20260108\_Aggreko\_Catladder-on-roof-D.pdf, 20260223-Buroh-St-Cat-ladder-COMMENTS.pdf, 20260225-QP-REPORT-FOR-CAT-LADDER-WAREHOUSE-For-Buroh-Street-ENDORSED.pdf, 20260225-QP-REPORT-FOR-CAT-LADDER-REPIR-CENTRE-For-Buroh-Street-ENDORSED.pdf. Codes cited: SS EN 1990, SS EN 1991-1-1, SS EN 1991-1-4, SS EN 1992-4, SS EN 1993-1-1, SS EN 1999, EN ISO 14122-4:2016, BS 8539, OSHA 29 CFR 1910.23.