

How Vehicle Mass Impacts Brake Design

Brake mass drivers: vehicle mass, wheel size, engine power, mass distribution and cooling

Brake Mass Sensitivities (from the study)

0.021 kg/kg

Brake system mass per kg of gross vehicle mass (thermal sizing)

-4 kg

Per +100 °C of allowed rotor temperature (AMS3, non-linear)

~195 g

Added brake mass per +10 mm tire static loaded radius

2.4-6 kg

Brake savings from aluminum vs steel wheels

~8 kg / 100 hp

AMS3 fade test, both 750 °C and 850 °C limits

1.0 g @ ≤100 bar

Common hydraulic pressure benchmark (pad $\mu \approx 0.32$)

~0.3 kg / 100 hp

AMS2, above the ~300 hp threshold

52-60% front

Weight-distribution range where brake mass peaks

Mass Decompounding Coefficients

Source	Coefficient	Meaning
Bjolkengren (brake + steering)	0.032	100 kg vehicle saving → 3.2 kg subsystem saving
Bjolkengren (brakes only)	≈ 0.024	
Malen	0.24	Higher estimate
GM internal	0.038 → 0.01	Earlier vs more recent work
This study (bottom-up thermal)	0.021	1500-2500 kg FWD, 64→24 kph repeat stops, 20 s intervals

Core Relationships

Brake torque need	$T_b = F_x \cdot r_{SLR}$	Bigger tire radius = longer moment arm = more torque for the same road force.
Disc brake torque	$T_b = 2 \mu p A_{piston} r_{eff}$	With p capped (~100 bar), larger radius forces larger pistons (standard relation).
Cascade	↑ piston → ↑ master cyl → ↑ booster → ↑ rear pistons	Larger pistons may need larger calipers, rotors and wheels.
Caliper example	57 mm @ 290 mm → 62 mm (or 2×44 mm) @ 370 mm	Front piston vs static loaded radius.

Fade Tests

AMS2	Cold stop from 100 km/h, then 10 back-to-back full-throttle accelerations and max-effort stops from 100 km/h. Measures fade resistance.
AMS3	9 cycles of WOT from 70 km/h to 80% of top speed, moderate braking back to 70 km/h, then a 10th stop from high speed. Peak rotor temperature is the key criterion.
AMS3 example	Meeting a 750 °C limit: brake mass 7 kg at 200 hp → over 28 kg at 500 hp.

Mass Distribution Effects (2100 kg GVW, z-critical 0.7 g, 1×60 mm front piston)

- Highly front-biased: small rear brakes suffice; front brakes are more mass-efficient → lower total mass.
- Less front bias: rear brakes must grow while fronts stay sized for pressure → mass rises.
- ~54% front: solid rear rotors no longer meet thermal limit → vented rear discs (heavier).
- Near 50/50: front load drops, both rotors shrink → mass falls.
- Below 50% front: rear piston grows; rear thermal limit governs sizing again.

Cooling vs Aero Trade-off

Change	Drag	Brake cooling / result
Open vs closed wheels (Wäschle / GM)	+15 counts (0.015 Cd)	+15-20% cooling
Front airdam (Jerhamre & Bergström)	-7 counts	-4% cooling
Reduced wheel vent area (D'Hooge et al.)	-22 counts	Less cooling
"Ski-ramp" duct case study	+8 counts → -0.18 mpg	+5% cooling; brakes 41.99 → 40.31 kg (-1.68 kg)

Sensitivities: 0.023 mpg lost per drag count · 0.045 mpg gained per 1% cooling · ~116 kg per mpg (≈ 0.008 mpg/kg). Offsetting the 0.18 mpg loss needs ~20.9 kg removed elsewhere.