Equivalent Standard Axles (Fourth-Power Law) and Design Traffic

Equivalent standard axle loads of a vehicle by the fourth-power law and the cumulative standard axles over a pavement design life with traffic growth.

Method: Fourth-power law (AASHO Road Test) and cumulative traffic with compound growth

Input parameters

Unit system: SI

Parameter	Value	Unit
Axle 1 load	60.000	kN
Axle 2 load	100.00	kN
Axle 3 load (0 if none)	100.00	kN
Standard axle load	80.000	kN
Damage exponent	4.0000	
Initial daily commercial vehicles (design lane)	1,500.0	
Annual traffic growth	5.0000	%
Design life (years)	15.000	

Calculated results

Parameter	Value	Unit
Vehicle damage factor (ESAL per vehicle)	5.1992	
Axle 1 factor	0.31641	
Cumulative growth factor (years)	21.579	
Cumulative standard axles (millions)	61.425	

Notes for this case

• Fourth-power law from the AASHO Road Test: damage per pass ∝ (P/P_s)⁴ for single axles. Tandem and tridem axles carry different equivalences in design codes; this treats each axle as single.

Formula and method

$$VDF = \sum \left(\frac{P_i}{P_s} \right)^m, \quad N = 365 A \, \frac{(1+r)^n - 1}{r} \, VDF$$

Variables

P_1	Axle 1 load	N
P_2	Axle 2 load	N
P_3	Axle 3 load (0 if none)	N
P_s	Standard axle load	N
m	Damage exponent	-
A	Initial daily commercial vehicles (design lane)	-
r	Annual traffic growth	-
n	Design life (years)	-
VDF	Vehicle damage factor (ESAL per vehicle)	-
$(P_1/P_s)^m$	Axle 1 factor	-

$\frac{(1+r)^n - 1}{r}$	Cumulative growth factor (years)	-
N	Cumulative standard axles (millions)	-

Method and standards

Empirical load equivalence and traffic growth.

Assumptions and limits

- Single axles, fourth-power equivalence, compound growth.

References

Fourth-power law (AASHO Road Test) and cumulative traffic with compound growth

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/civil/roads/fourth-power-law-esal

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.