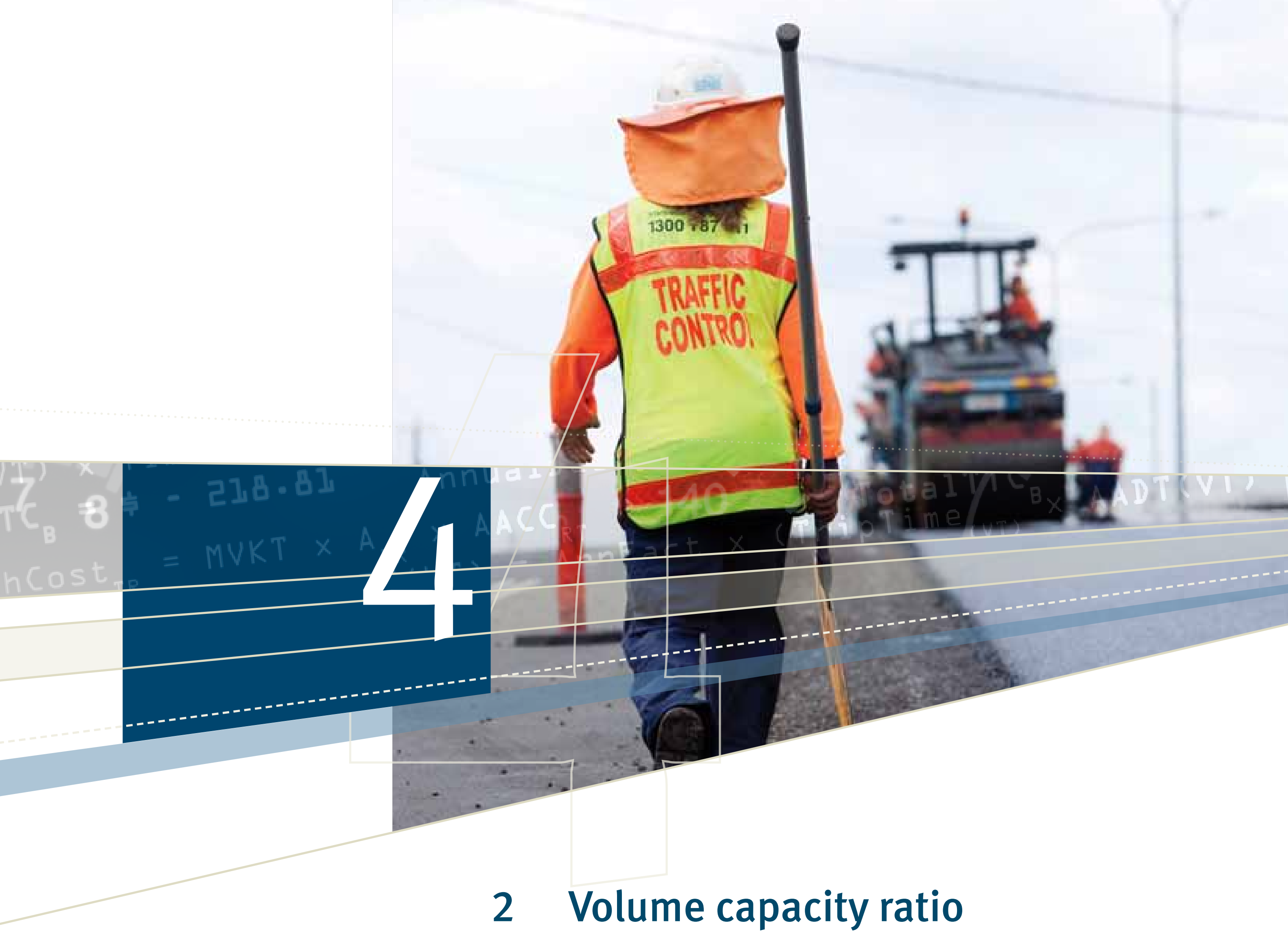


## 2 Volume capacity ratio

This section of the *Technical Guide* outlines the equations used in the derivation of the VCR and the calculations of traffic volume and road capacity. The VCR is an important calculation in CBA6 as it is central to the calculation of operating speed and many of the congestion adjustments in the VOC algorithms.

## 2.1 Traffic volume

AADT and vertical alignment inputs to CBA6 are used to calculate the volume of traffic on the road using passenger car equivalents (PCE). The AADT value is converted into PCEs to measure traffic volume.

PCE factors for each vehicle type are shown by Table 1 for example, a B-double on a section of road with an entire grade of 4% is equivalent in volume to 8.1 passenger cars.

*Table 1: Passenger car equivalent factors*

| Vehicle type | Flat | Grade 4% | Grade 6% | Grade 8% | Grade 10% |
|---|---|---|---|---|---|
| Cars– private | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| Cars – commercial | 1.0667 | 1.1667 | 1.3333 | 1.6667 | 2.0000 |
| Non-Articulated | 1.4000 | 2.1000 | 2.8000 | 4.2000 | 5.2222 |
| Buses | 1.7000 | 3.0000 | 4.0000 | 6.0000 | 7.0000 |
| Articulated | 2.4000 | 4.8000 | 7.2000 | 9.6000 | 12.0000 |
| B-double | 4.1000 | 8.1000 | 12.2000 | 16.2000 | 20.3000 |
| Road train 1 | 4.9500 | 9.8500 | 14.8500 | 19.7500 | 24.7000 |
| Road train 2 | 8.8000 | 17.6000 | 26.5000 | 35.3000 | 44.1000 |

*Source: adapted from Austroads (2005) page 20.*

The formula to calculate the traffic volume is shown by Equation 1.

*Equation 1: Traffic volume*

$$Volume = \sum_i AADT_i \times PCE_i$$

Where:

- $AADT_i$ = annual average daily traffic count
- $PCE_i$ = passenger car equivalent for vehicle type i

*Example: Traffic volume*

On a flat road (100% flat) with AADT of 1000, made up of 616 private cars, 264 commercial cars, 50 rigid vehicles, 10 buses, 50 semis and 10 B-doubles, the corresponding traffic volume is given by:

$$Volume = (616 \times 1) + (264 \times 1.0667) + (50 \times 1.4) + (10 \times 1.7) + (50 \times 2.4) + (10 \times 4.1)$$

$$Volume = 1146$$

Therefore the traffic volume of the road in PCE is 1146. This is notably different from the AADT of 1000.

## 2.2 Traffic growth rate

CBA6 uses the traffic growth rate to calculate the VCR in future years. CBA6 provides two growth options when predicting future traffic volumes, linear growth and compound growth. For further details on the suitability of either growth rate option, see Section 3.5.3.2 of the *User Guide*. The calculation of linear and compound growth rates is given in Section 2.2.1 and Section 2.2.2 respectively.

### 2.2.1 Linear traffic growth

The formula to calculate AADT when the traffic growth rate is linear is given in Equation 2.

*Equation 2: Linear traffic growth*

$$AADT_x = AADT_{y1} + (x - y1) \times \left(\left(AADT_{y1} \times (1 + GR)\right) - AADT_{y1}\right)$$

Where:

- $AADT_{y1}$ = AADT in the first year of evaluation
- $AADT_x$ = AADT in year x
- GR = growth rate
- y1 = first year (1)
- x = year of calculation

*Example: Linear traffic growth*

AADT for a given road is 1000 and the linear growth rate is assumed to be 3% p.a. AADT in Year 5 is given by:

$$AADT_5 = 1000 + (5 - 1) \times \left(\left(1000 \times (1 + 0.03)\right) - 1000\right)$$

$$AADT_5 = 1120$$

Note: When using the linear growth forecast, future trends are based solely on the AADT in the year selected for extrapolation.

### 2.2.2 Compound traffic growth

The formula for compound traffic growth is shown by Equation 3.

*Equation 3: Compound traffic growth*

$$AADT_x = AADT_{y1} \times (1 + GR)^{(x - y1)}$$

A compound growth rate is a growth rate which is compounded annually, whereas a linear growth rate results in a constant increase in traffic each year.

*Example: Compound traffic growth*

Using an AADT of 1000, compounded annually at 4% for 5 years, the calculated AADT is given below:

$$AADT_5 = 1000 \times (1 + 0.04)^4$$

$AADT_5 = 1169.86$

As demonstrated in this example, AADT can vary substantially depending on the type of growth rate applied. Compound growth in AADT is based on a constant percentage increase in the number of vehicles per year, while linear growth in AADT is based on a constant increase in the actual number of vehicles per year.

## 2.3 Road capacity

Road capacity is dependent on both the hourly capacity, measured in PCEs, and a peak hour capacity factor by model road state (MRS).

Table 2 lists the hourly capacities in PCE for each MRS. Hourly capacity is dependent on the seal type (undivided or divided) and the seal width.

*Table 2: Hourly PCE capacity*

| MRS | Road width description | Hourly capacity (PCE/hr) |
|---|---|---|
| 1 | Unsealed natural surface | 400 |
| 2 | Unsealed formed road | 400 |
| 3 | Paved < 4.5 m | 500 |
| 4 | Paved >= 4.5 m | 700 |
| 5 | Narrow seal <= 4.5 m | 1 500 |
| 6 | Narrow seal 4.6 m–5.2 m | 2 000 |
| 7 | 2 lane seal 5.3 m–5.8 m | 2 300 |
| 8 | 2 lane seal 5.9 m–6.4 m | 2 350 |
| 9 | 2 lane seal 6.5 m–7.0 m | 2 450 |
| 10 | 2 lane seal 7.1 m–7.6 m | 2 500 |
| 11 | 2 lane plus shoulder seal 7.7 m–8.2 m | 2 525 |
| 12 | 2 lane plus shoulder seal 8.3 m–9.0 m | 2 550 |
| 13 | 2 lane plus shoulder seal 9.1 m–9.4 m | 2 550 |
| 14 | 2 lane plus shoulder seal 9.5 m–10 m | 2 565 |
| 15 | 2 lane plus shoulder seal 10.1 m–11.6 m | 2 575 |
| 16 | 3 lane for overtaking | 4 000 |
| 17 | 4 lane undivided sealed | 7 120 |
| 18 | 6 lane undivided sealed | 12 000 |
| 19 | 4 lane divided sealed | 8 000 |
| 20 | 6 lane divided sealed | 12 000 |
| 21 | 4 lane divided (limited access) | 8 000 |
| 22 | 6 lane divided (limited access) | 12 000 |
| 23 | 8 lane divided (limited access) | 16 000 |

*Source: adapted from Austroads (2005) page 22.*

Note: MRS is derived from the Western Australia MRS classification: Austroads (AP-R264/05).

Default peak hour capacity percentages are shown by Table 3. These default figures are used to assess the percentage of AADT that travel during peak periods.

*Table 3: Road type and peak hour capacity factor*

| Road type | Capacity factor |
|---|---|
| National highway | 10 |
| Urban single carriageway | 10 |
| Urban dual carriageway | 12.5 |
| Rural single carriageway | 8.33 |
| Rural dual carriageway | 10 |

*Source: TMR.*

TMR assumes that 10% of AADT on a national highway travels during peak periods. Similarly, 12.5% of daily traffic travels in peak periods on urban dual carriageways.

Equation 4 is used to calculate the capacity for a given road.

*Equation 4: Road capacity*

$$Capacity = \frac{Hourly\ Capacity}{Capacity\ Factor\ \%}$$

Where:

- Hourly Capacity = hourly capacity in PCE/hr by MRS
- Capacity Factor% = proportion of daily traffic in the peak periods

The hourly capacity rate is set by the corresponding MRS and is a function of the seal width. In CBA6, roads with larger seal widths are assumed to accommodate more vehicles per hour.

*Example: Road capacity*

A national highway with a model road state of 10 would have an hourly capacity of 2500, see Table 2, and a peak hour capacity factor of 10%, see Table 3. In this example, the road capacity is given below:

$$Capacity = \frac{2500}{10\%}$$

$$Capacity = 25{,}000$$

Note: Peak period (1 hour) is determined in CBA6 based on the system user's selection of road description and MRS. The capacity factor is thus used to determine the capacity of the road which in turn influences the VCR. This form of modelling is known as free flow.

## 2.4 Volume capacity ratio

VCR is calculated using the volume calculations shown by Section 2.1 and the capacity calculations shown by Section 2.3.

*Equation 5: Volume capacity ratio*

$$VCR = \frac{Volume}{Capacity}$$

Where:

- For further information on VCR, see Section 2.1

The VCR is a measure of the level of congestion on a road given the traffic volume and road capacity. When the VCR reaches 1, this indicates that the road is operating at 100% capacity.

Note: The maximum VCR in CBA6 is 1.25.

*Example: Volume capacity ratio*

Using the examples provided in Sections 2.1 and 2.3, the corresponding VCR is:

$$VCR = \frac{1145}{25{,}000}$$

$$VCR = 0.046$$

This example illustrates that the current road volume is approximately 4.6% of total road capacity.