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EQUIPMENT SELECTION & SIZING

# Belt Conveyor Capacity: Belt Width, Speed and Surcharge Angle

Size a belt conveyor with Q = 3600*A*v*rho, work two examples, and learn why width beats speed and which limits (lump size, surcharge) the equation hides.

**Author:** Sivabalan Selvarajan

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A conveyor that is too narrow spills and chokes; one that is too wide and fast wastes capital and power. Sizing it correctly comes down to one tidy equation that links belt width, speed and the material's bulk density — and to respecting two limits the equation does not show: lump size and the angle the load will stand at.

This article derives the capacity relation, sizes a belt two ways, and lays out the width-versus-speed trade-off that decides whether a conveyor runs quietly for twenty years or wears itself out chasing tonnage.

## The capacity equation

Capacity is the cross-sectional area of material on the belt, carried past a point at the belt speed, times the bulk density:

$$Q = 3600\,A\,v\,\rho$$

with $Q$ in t/h, the load cross-section $A$ in $m^2$, belt speed $V$ in m/s and bulk density $\rho$ in $t/m^3$. The cross-section $A$ grows with belt width and with the trough and surcharge angles — the angle the material naturally heaps at.

| SYMBOL | MEANING | UNITS |
|---|---|---|
| Q | Capacity | t/h |
| A | Load cross-sectional area | m2 |
| v | Belt speed | m/s |
| ρ | Bulk density | t/m3 |

## Worked example 1

An 800 mm troughed belt carries crushed stone ($\rho = 1.6\,t/m^3$) with a load cross-section $A = 0.030\,m^2$ at $v = 2.5\,m/s$:

$$Q = 3600 \times 0.030 \times 2.5 \times 1.6 = 432\ t/h.$$

Figure 1 shows how capacity scales with speed for three belt widths.

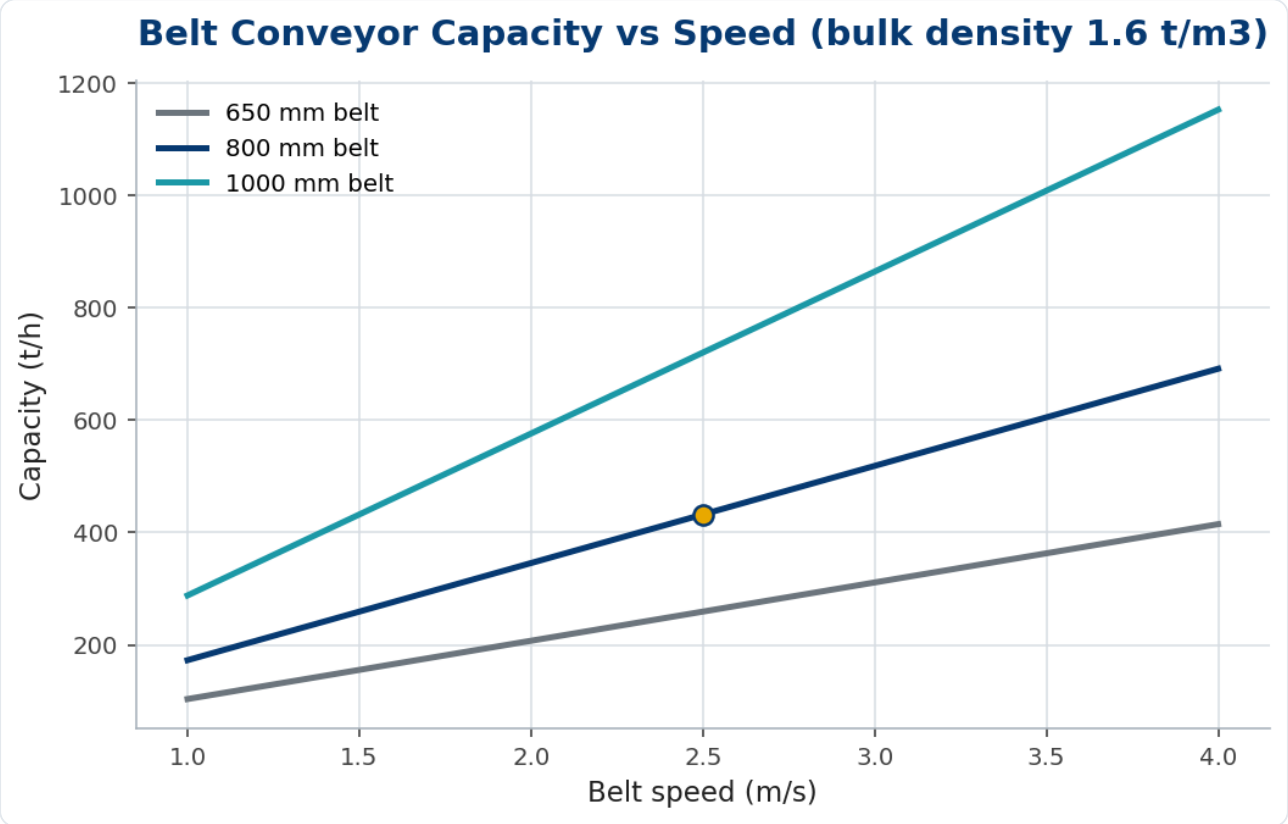



Figure 1. Capacity is linear in speed and grows fast with width (area ∝ width squared). The marked point is the worked example.

## Width or speed?

The equation offers two routes to capacity — a wider belt or a faster one — and they are not equivalent. Cross-section grows roughly with the square of belt width, so widening is a powerful and gentle way to add capacity. Speeding the belt adds capacity linearly but raises wear, noise, degradation of the rock and the risk of spillage and belt mistracking. As a rule, reach for width first and keep speed in a sober band (often 2–3.5 m/s for crushed aggregate).

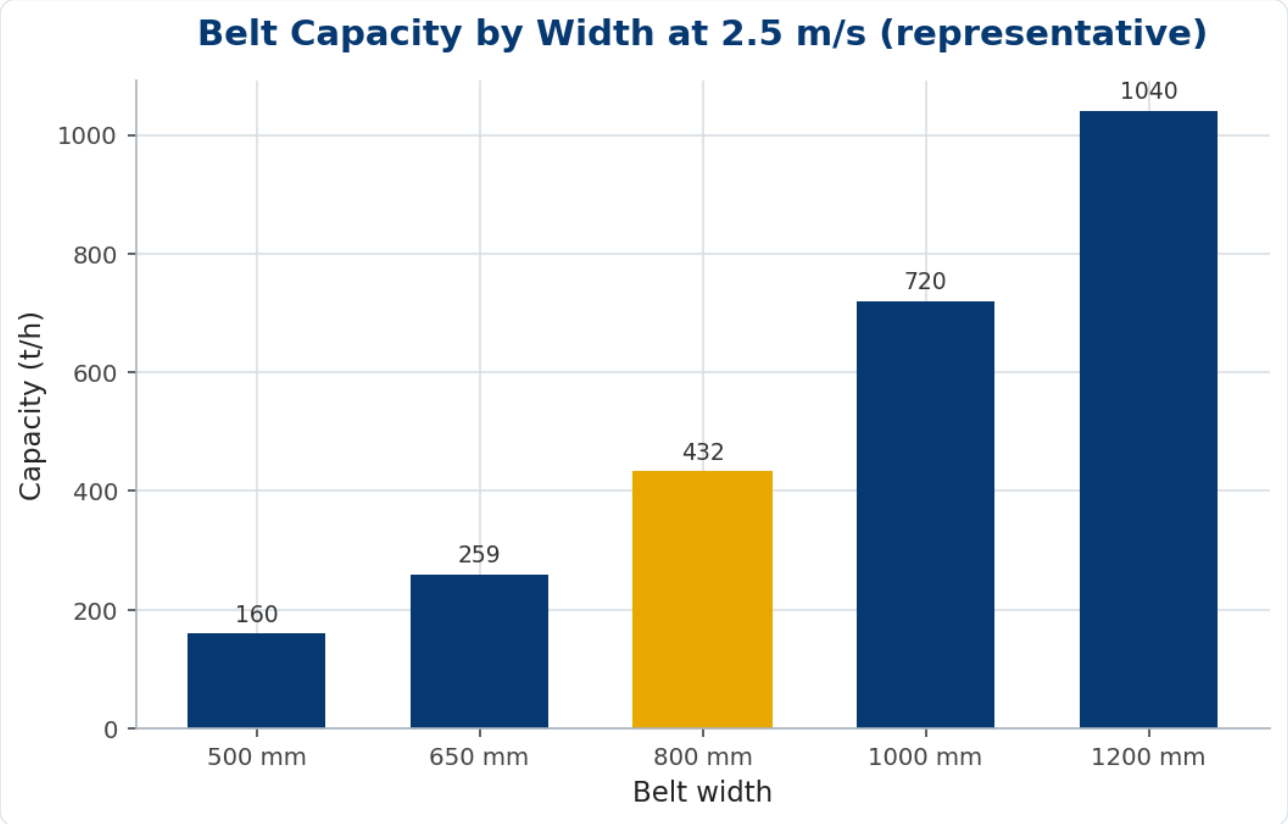



Figure 2. At a fixed speed, capacity climbs steeply with width — the cheapest, kindest tonnes come from a wider belt, not a faster one.

## The two limits the equation hides

Capacity is necessary but not sufficient. Two physical limits must also pass. First, **lump size**: the belt must be wide enough to carry the largest lumps without bridging the skirts — a common rule is a belt width of at least 2–3 times the top size for unsized rock. Second, the **surcharge angle**: free-flowing rounded material stands at a low angle and fills less cross-section than the equation’s ideal, while sticky or angular material stands higher. Both adjust the real $A$ away from the textbook value.

| CHECK | RULE OF THUMB | IF IT FAILS |
|---|---|---|
| Lump size | belt width ≥ 2–3 × top size | widen the belt |
| Surcharge angle | use the material's real angle, not 20° ideal | re-rate A |
| Speed | ~2–3.5 m/s for crushed stone | widen rather than speed up |

## Worked example 2 — sizing for a duty

A circuit needs to move 500 t/h of 0–40 mm crushed stone. At $v = 2.5\,\text{m/s}$ and $\rho = 1.6\,\text{t/m}^3$, the required cross-section is $A = Q/(3600 v \rho) = 500/(3600 \times 2.5 \times 1.6) = 0.035\,\text{m}^2$ — an 800 mm belt run a touch fuller, or a 1000 mm belt with comfortable freeboard. With 40 mm top size the lump-size rule (belt ≥ ~120 mm) is trivially met, so width is set by capacity and freeboard, and a 1000 mm belt at 2.5 m/s is the kinder, longer-lived choice.

## In practice

Run belts a little below their theoretical capacity — aim to fill the cross-section to about 70–75%, leaving freeboard for surges and off-centre loading. Load in the direction of travel and centrally to protect tracking and the belt edges. And remember the capacity equation says nothing about power: that comes from belt length, lift and friction, and is a separate calculation — a short, level belt and a long, inclined one of the same capacity draw very different motors.

## Common mistakes

- **Running belts brim-full.** Leave freeboard for surges; design to ~70–75% of the theoretical cross-section.
- **Speeding up instead of widening.** Width adds capacity with the square and far less wear; speed adds it linearly with more.
- **Using the ideal surcharge angle.** Free-flowing rock stands lower than 20°; rate $A$ on the real material.

## Power and tension: the other half of conveyor design

Capacity sizes the belt to carry the tonnes; power and tension size the drive to move them. The two are independent: a conveyor can have ample cross-section yet stall or tear its belt if the drive and tension are wrong. The effective tension the drive must develop is the sum of the forces resisting the belt — the friction of carrying the load and belt along the idlers, plus the force to lift the material through any rise:

$$T_e = F_{friction} + F_{lift}, \qquad P = \frac{T_e v}{1000}$$

where $P$ is the drive power in kilowatts, $T_e$ the effective tension in newtons and $V$ the belt speed in m/s. The lift term is the one that surprises: raising material is expensive, so a long, steep conveyor can demand far more power than its tonnage alone would suggest, while a long horizontal one is dominated by rolling friction.

Tension also has a floor set by the drive geometry, not just the load. The belt must grip the drive pulley without slipping, which requires a minimum tension on the slack side — provided by gravity take-up or a screw take-up — and it must not sag so far between idlers that material spills. Too little tension slips and spills; too much overloads the belt, pulleys and bearings, exactly the window the designer must hit.

So design a conveyor in two passes: cross-section and speed for the capacity, then tension and drive power for the resistances — friction plus lift — with adequate take-up to grip the pulley. A belt sized only for capacity, on an under-powered or under-tensioned drive, is a conveyor that carries the tonnes on paper and slips, sags or stalls in the yard.

## The bottom line

Belt capacity is $Q = 3600\,A v \rho$, and the craft is in the cross-section: it grows with the square of width, so widening is the gentle way to add tonnes. Keep speed sober, leave freeboard, and clear the lump-size and surcharge checks the equation hides.

Size for the duty with margin and load the belt centrally, and a conveyor becomes the most reliable machine in the plant — which is exactly what it should be.

# Frequently asked questions

## Should I widen the belt or speed it up?

Widen first. Cross-section grows with the square of width, adding capacity gently; higher speed adds it linearly but raises wear, noise and spillage risk.

## How wide must the belt be for my lump size?

A common rule is a belt width of at least 2–3 times the top size for unsized rock, so the largest lumps clear the skirts.

## Does the capacity equation give the motor size?

No. Power depends on belt length, lift and friction — a separate calculation. Two belts of equal capacity can need very different motors.

### Key takeaways

- $Q = 3600 A v \rho$ — area in m2, speed in m/s, density in t/m3.
- Cross-section grows with the square of belt width, so widen before you speed up.
- Clear the hidden checks: lump size (belt ≥ 2–3 × top size) and the real surcharge angle.
- Leave freeboard (~70–75% fill); size power separately from capacity.

**Topics:** #Capacity #Equipment Sizing #Materials Handling #belt conveyor