MAREFORGE

Passive load sharing in a roller cassette

A mechanism study of height mismatch travel and service access

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Two rollers can be present while one carries most of the load. This study explores a removable rocker cassette that changes height at its two ends, allowing a pair of contacts to redistribute load without powered adjustment.

In the declared spring benchmark, a 3 mm height mismatch produces a 75/25 split with locked geometry. A free rocker with the selected moment budget gives approximately 51/49. The useful design decision is a 440 mm roller pitch: shorter alternatives consume the travel needed for mismatch, unequal stiffness and assembly variation.

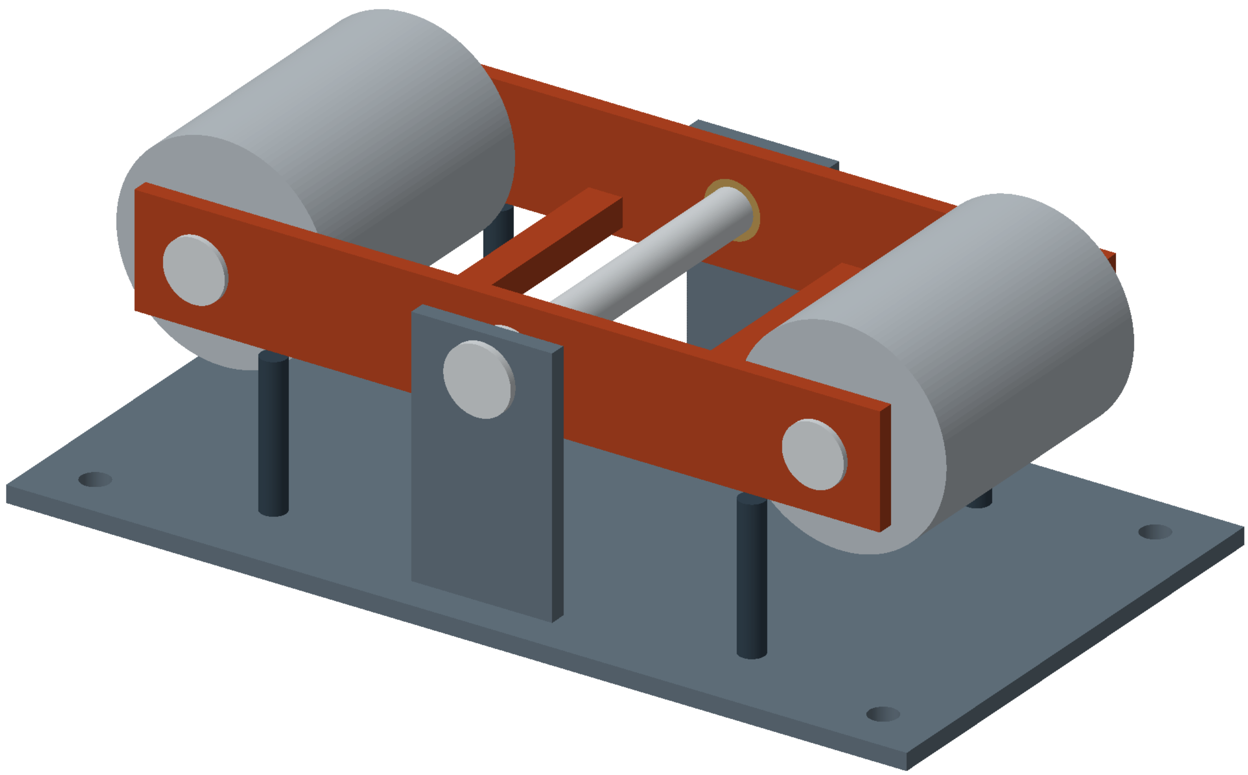

Figure 1. Original 3D concept assembly, with 34 component instances. Grey rollers rotate on axles carried by the orange rocker. The rocker pitches about the central pin. Fastening details are represented only at envelope level.

What this sample establishes

The sample connects a functional target to mechanism geometry, tolerance allocation and a verification plan. It includes an editable STEP concept and reproducible calculations. It is an illustrative design study with hypothetical requirements, not a delivered project or tested product. The spring benchmark does not establish actual cable contact loads, allowable curvature or equipment capacity.

1 Define the behaviour before sizing parts

The intended function is to share a slowly applied normal load between two support rollers despite small differences in interface height. A guided platen and two compression springs form the analytical benchmark. They isolate the mechanism behaviour; their stiffness values are not inferred from a real cable.

Study input or target	Value	Reason for inclusion
Total applied contact load P	2 to 6 kN	Defines the benchmark envelope
Stiffness of each interface k	0.8 to 1.2 kN/mm	Tests unequal compliance
External height mismatch	Up to 8 mm	Assumed fixture requirement
Differential assembly allowance	1.0 mm	Two height stacks at ±0.5 mm
Analysed rocker travel	±1.5 degrees	Limits the working motion
Maximum share at one contact	55% of P	Defines acceptable imbalance
Remaining travel reserve	At least 1.0 mm	Kept beyond the stated stack
Selected net moment budget	30 N m	Test target derived on page 3

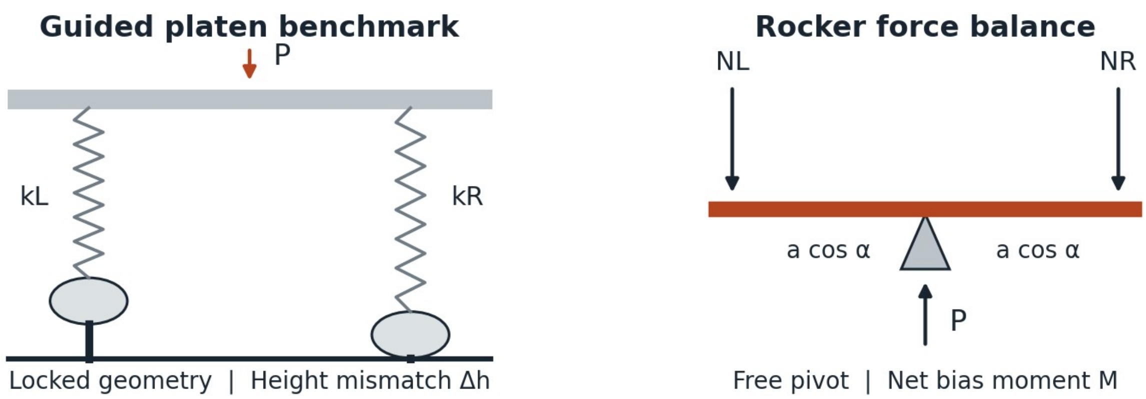

Figure 2. Analytical idealisations. Height offsets are exaggerated. The total contact load is P; cassette self weight is separate. Weight eccentricity and other pitch moments must be included in the net moment budget.

For locked geometry and equal stiffness, force compatibility gives $N_L - N_R = k\Delta h$ while both contacts remain engaged. At $P = 6$ kN, $k = 1$ kN/mm and $\Delta h = 3$ mm, the reactions are 4.5 and 1.5 kN. Once $k|\Delta h|$ reaches P, the lower contact unloads. A negative contact force must not be retained in the model.

2 Give the load a way to equalise

The roller axes lie at equal distances a from the central pivot. For vertical contact forces and pitch angle α, the horizontal lever arm is a cos α. Away from the stops, equilibrium constrains the load difference through the net pitch moment M.

$$N_L + N_R = P$$

$$|N_L - N_R| = \frac{|M|}{a \cos \alpha}$$

M includes pivot resistance, seal drag, weight eccentricity and any other pitch bias transmitted into the rocker. Treating M as zero without checking those effects would overstate the benefit. With both contacts engaged, a bounded static resistance gives a bounded load imbalance; it does not guarantee a unique resting angle.

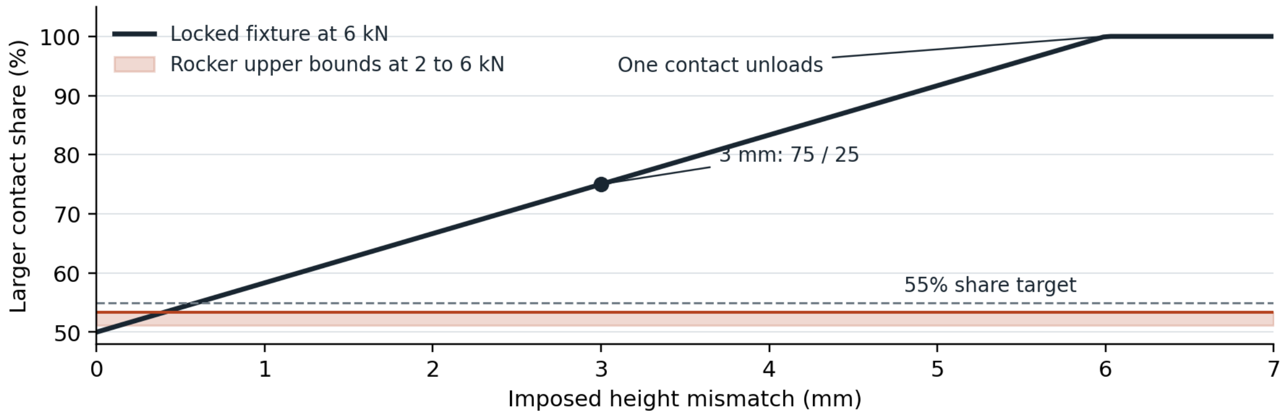

Figure 3. Calculated fixture behaviour. Locked curve uses equal k = 1 kN/mm and P = 6 kN. Rocker band uses a = 220 mm, |M| ≤ 30 N m and |α| ≤ 1.5 degrees. It applies only with free travel and both contacts engaged; it is not test data.

Derive a measurable moment requirement

A 55/45 maximum split means the force difference must remain below 10% of P. The lowest load, 2 kN, therefore governs the allowed moment. At a = 220 mm and α = 1.5 degrees, the mathematical ceiling is 44.0 N m. The selected 30 N m budget leaves about 14 N m below that ceiling and limits the larger share to 53.4% at 2 kN.

At the 6 kN, 3 mm baseline, the signed 30 N m equilibrium branch gives 3.068 and 2.932 kN at a pitch of 0.373 degrees. These are calculated conditional values. Breakaway resistance, hysteresis and cable drag must be measured before the same behaviour can be claimed for hardware.

3 Spend the travel budget deliberately

The rocker needs travel for more than the external height offset. Unequal spring compression and assembly variation also consume motion. This is why choosing the shortest cassette from the nominal geometry alone gives a weak design.

$$H_{available} = 2a \sin\alpha_{max}$$

At 6 kN, interfaces of 0.8 and 1.2 kN/mm require 1.25 mm of differential compression even with an equal force split. The net moment budget adds a small compliance term. A conservative demand bound for the stated positive contact forces is:

$$H_{required} = 8 + 1 + 1.25 + \frac{M_{budget}}{2a \cos\alpha_{max}} \left(\frac{1}{k_{min}} + \frac{1}{k_{max}} \right)$$

Use N, mm and N mm in this equation. The 8 mm term is the external mismatch, 1 mm is the assembly allowance, and 1.25 mm is the maximum equal load compression difference. Stiffness limits are 800 and 1200 N/mm.

Roller pitch	Available travel	Required travel	Reserve
360 mm	9.424 mm	10.424 mm	−1.000 mm
400 mm	10.471 mm	10.406 mm	0.064 mm
440 mm	11.518 mm	10.392 mm	1.126 mm

The 360 mm pitch lacks travel. The 400 mm pitch fits the mathematical demand but leaves almost no tolerance beyond it. The 440 mm pitch is the shortest of the three options that preserves the selected 1 mm remaining reserve. This costs 80 mm of pitch compared with the compact option and produces a 640 × 360 mm base envelope.

Keep working travel clear of the stops

The CAD concept uses stop envelopes near ±2 degrees, while the analysis is limited to ±1.5 degrees. Geometric intersection checks found no interference at −1.5, 0 and +1.5 degrees; a 2.2 degree trial intersects the stops. These checks establish clearance at the sampled positions, not continuous motion validation or stop strength.

The calculation file also solves 405 combinations of load, stiffness, signed mismatch and signed moment. The greatest required angle on that grid is 1.353 degrees. The analytical travel bound supplies the envelope; the grid checks the numerical implementation.

4 Make the mechanism removable and inspectable

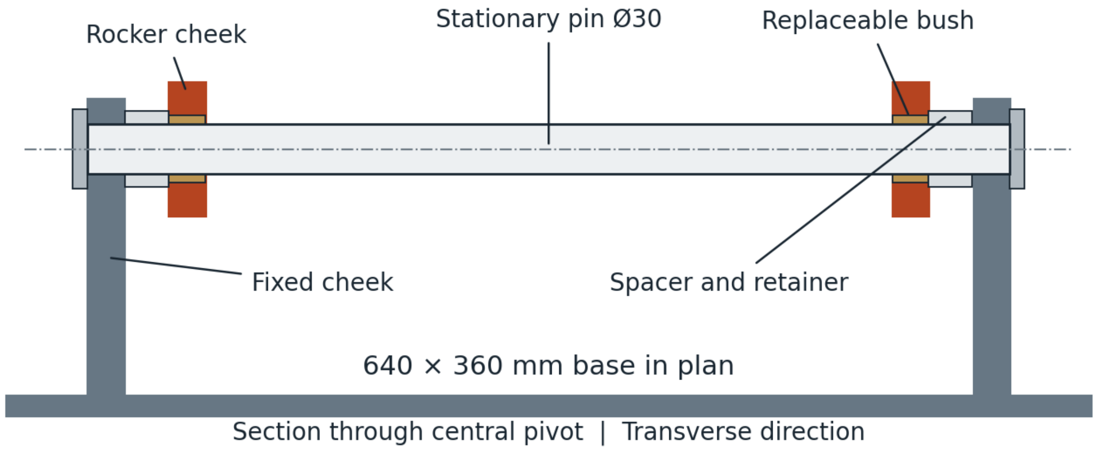

Figure 4. Central pivot section from the concept dimensions. The Ø30 mm pin is stationary; the bushes move with the rocker. Running fits, lubrication, seals and positive fastening details require specification.

Element	Concept arrangement	Design intent
Roller module	Two Ø150 × 200 mm rollers	Replace contact bodies independently
Rocker	Two 12 mm cheeks with cross ties	Keep both roller axes in one assembly
Central pivot	Ø30 mm pin with replaceable bushes	Provide the equalising degree of freedom
Axial retention	Spacers and retaining discs	Define the retention envelope
Travel stops	Four stop envelopes	Limit excessive pitching
Fixed base	640 × 360 × 12 mm plate	Provide an installation interface

Service access changes the preferred architecture

Removing the cassette requires supporting and unloading it, releasing the pivot retention and withdrawing the 306 mm pin. The concept reserves approximately 350 mm of side access for withdrawal and handling. If that space is unavailable, removal of the whole base or a different support arrangement may be preferable.

The retaining discs in the STEP file show where retention belongs; they are not a complete fastener design. Axial bolts or another positively secured arrangement, pin anti rotation, lifting provisions and the unloaded removal method must be detailed. Threads, welds, manufacturing fits and guards have not been specified.

The Ø150 mm rollers are geometric placeholders for the contact interface. The cassette accommodates support height differences; it does not establish cable minimum bend radius, allowable local compression or lateral containment. Those requirements can change the roller bodies and the whole layout.

5 Verify the mechanism and its limits

Equalisation should not be used to assume that each axle can only see half the total load. A seized pivot, an engaged stop or lost contact changes that distribution. The following nominal bending demands use the concept Ø30 mm pins and axles, without material allowables or dynamic amplification.

Nominal case	Maximum moment	Bending demand
Roller axle at baseline maximum share	53.7 N m	20.3 MPa
One roller carrying the full 6 kN	105 N m	39.6 MPa
Central pin with symmetric load entry	81 N m	30.6 MPa

Each roller axle has simple supports 240 mm apart and two equal bush loads at 170 mm centres, leaving 35 mm between each load and adjacent support. The central pin has supports 294 mm apart and two loads at 240 mm centres, leaving 27 mm. Loads act at the nominal bush centres. Dead weight, local bearing stresses, joints and side loads remain additional checks. These are stress demands, not pass results.

A test programme that could disprove the concept

- Calibrate the two fixture compliances and the load cells, then verify force balance with the rocker locked. Apply known height offsets and compare with the unilateral contact model.
- Release the rocker and measure both reactions and pitch over 2 to 6 kN, reversing the height offset and load direction. Target a larger share no greater than 55%, with both contacts engaged throughout the declared working range.
- Measure breakaway and running moment for the whole assembly, including retention, sealing and representative contamination. The selected budget is 30 N m; it has not been demonstrated.
- Exercise the travel limits separately and check stop, retention and support loads. Complete cable compatibility, fatigue, corrosion, guarding and installation checks for the intended duty before release.

Principle background and related scope

Load equalisation through tilting supports is established mechanical practice. Kingsbury explains equalising and non equalising thrust bearing arrangements. That source supports the general principle; it does not validate this cassette. The geometry, benchmark and calculations here are original. Accessed 12 September 2026.

Marine routing and installation interfaces connect to Marine and Offshore Engineering.

A mechanism with confirmed inputs can progress through Equipment and Product Development; uncertain requirements can first be resolved through a defined technical assessment.