What Carries Most of an External Load Is Not the Bolt

— an external load of 10000 N on an M10 bolt raises its tension by only **1975.3460** N, the rest being taken up as the clamped members decompress — the joint does not separate until the load is **1.246160** times the preload — [Paper 556]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
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— From thinking to syncing. —

Abstract

When an external load pulls on a bolted joint, the bolt is taken to carry it.What this paper shows is that the load divides by stiffness, that the majority falls on the clamped members, and that this conclusion survives a badly uncertain assumption.No new theorem or law is claimed. First, the members carry the majority——of 10000 N the bolt takes 1975.3460 N and the members 8024.6540 N, a ratio of 4.062404 (Section 3). **Second, and this is the core.The conclusion does not move when the assumption does——varying the member geometry moves the share 4.394554-fold and leaves the bolt below half throughout** (Section 2). **Third, one of those cases meets the textbook figure——at twice the bolt diameter the share is 0.197535, within 0.005 of the customary 0.2** (Section 2). **Fourth, separation needs more than the preload——a joint preloaded to 30000 N holds to 37384.7894 N, 1.246160 times as much** (Section 3). **Fifth, at separation the bolt's share jumps 5.06-fold——from 0.197535 to one, passing through nothing between** (Section 4). **Sixth, the separator is whether the members are still in compression——once they separate, the bolt takes the whole of the external load** (Section 4). **Keywords**: bolted joint, load sharing, stiffness ratio, preload, torque coefficient.

Scope of this paper (scope note): **No new theorem or law is claimed——the division of an external load by joint stiffness, and the torque coefficient, are standard.No design is recommended——what preload to choose is not stated; only what happens under load.Member stiffness is approximated by a cylinder——the compression actually spreads as a frustum, which is why the values themselves are not relied on and the outer diameter was instead swung from 1.5 to 3.0 times the bolt diameter to see whether the conclusion moved.Only the elastic range is treated——yielding, thread shear and embedding relaxation are excluded.Loosening and cyclic loading are not treated——neither rotational loosening nor fatigue is the subject.The relation between tightening torque and preload is not computed——how much of a wrench's torque arrives as axial force was already measured in Paper 463, where 11.61 per cent of the 718.0783-fold that geometry promises actually arrives. This paper does not enter there, and begins where the preload is given.It is not said that tightening makes a joint safe——more preload delays separation and leaves the bolt less margin of its own.Relation to earlier papers**: **Paper 477 showed that while the wrong input is being added, the limit is somewhere else——"the bolt may be thickened while the members carry eight tenths of the load" is the same shape, though that one concerns the location of a limit and this one a division of load, which can itself change as the load grows.Paper 550 showed that a line's capacity is its minimum stage——both are of the form "what decides is the arrangement, not the parts", but there the unselected side contributed exactly nothing while here the inconspicuous side carries the majority: the contribution vanishes in opposite ways.Paper 463 showed that of the sevenhundredfold geometry promises, one tenth arrives——that paper concerns the act of tightening and this one what follows it: its endpoint, the preload achieved, is this paper's starting point. One bolt, seen over two different intervals of time.Paper 300 showed that sharing a root is decidable——"the load divides by stiffness" and "separation needs more than the preload" are separate roots.**What is added is **swinging the member geometry over four settings and measuring the 4.394554-fold spread**, **confirming the bolt stays below half in all of them**, **matching one case to the textbook 0.2 within 0.005**, **inverting the separation load to confirm the compression returns to exactly zero**, and **showing that the bolt's share jumps 5.06-fold across separation**.

1. Notation and the Question

Setting: **a bolt clamps two plates; the bolt is stretched and the plates are compressed.Writing k_b for the bolt stiffness and k_m for that of the clamped members, an external load F raises the bolt tension by**

$$\Delta F_b = \phi F, \qquad \phi = \frac{k_b}{k_b + k_m}$$

while the remaining $(1-\phi)F$ is taken up as the members decompress.

> **Observation 1.1**
>
> intuition expects $\phi = 1$.“It is being pulled, so the bolt takes it”——yet while the plates remain compressed, part of the load is absorbed by their relaxing.

> **Observation 1.2**
>
> k_m exceeds k_b.The bolt is long and slender, the plates short and broad——the stiffer party takes the larger share, so the plates are the majority.

Question: what is ϕ?And since k_m cannot be pinned down, can anything be concluded regardless?

2. The Conclusion Does Not Move When the Assumption Does

Computation 2.1: a steel M10 bolt of stress area $58\ \text{mm}^2$ over a grip of 40 mm gives $k_b = EA_s/L = 2.987000 \times 10^8$ N/m.The members are taken as a hollow cylinder with an inner diameter equal to the bolt, and the outer diameter is swung over four settings.

member outer diameter	k_m/k_b	bolt share ϕ
1.5 times	1.692668	**0.371379**
2.0 times	4.062404	**0.197535**
2.5 times	7.109208	**0.123317**
3.0 times	10.833078	**0.084509**

> **Observation 2.2**
>
> the values themselves move a great deal.From **0.084509** to **0.371379**, a factor of **4.394554**——above 4 and below 5. The compression actually spreads as a frustum, so no particular outer diameter can be settled on, and the numerical value of ϕ cannot be relied on.

Observation 2.3

this is the core.Yet ϕ stays below half in all four——swinging the assumption $\mathbf{4.394554}$-fold leaves the bolt in the minority. Where a number cannot be trusted, an inequality still can.

Observation 2.4

one case meets the textbook figure.At twice the bolt diameter, $\mathbf{0.197535}$ lies within 0.005 of the customary 0.2——a comparison with a value fixed outside this work.

Observation 2.5

the direction was checked too.Stiffer members give a monotonically smaller ϕ——movement the other way would mean the formula is wrong.

3. Where It Separates, and Where the Work Goes

Computation 3.1: **at twice the bolt diameter ($\phi = \mathbf{0.197535}$), under an external load of 10000 N.**

quantity	value
increase in bolt tension	**1975.3460** N
decrease in member compression	**8024.6540** N
members divided by bolt	**4.062404**

Observation 3.2

the two sum back to the load.10000 N, to 12 digits——a division, with nothing disappearing.

Observation 3.3

the shape of Paper 477.The bolt may be thickened while the members carry eight tenths of the load—— while the wrong input is being added, the load is elsewhere. That paper concerns the location of a limit and this one a division of load, which can itself change as the load grows.

Computation 3.4: **the load at which a joint preloaded to 30000 N separates.**

quantity	value
separating load	**37384.7894** N
relative to the preload	**1.246160**

Observation 3.5

it holds past the preload.1.246160 times, above 1.2 and below 1.3——the far side of the intuition that "preloaded to 30000 N, it separates at 30000 N". Because the bolt absorbs part of the load, there is room before the compression reaches zero.

Observation 3.6

the inversion is a check.Feeding that load back brings the member compression to exactly zero, within 10^{-9} ——confirming separately that it solves the equation.

Observation 3.7

where that preload came from is not asked here.How much of a wrench's torque arrives as axial force was already measured in Paper 463——11.61 per cent of the 718.0783-fold that geometry promises. That paper concerns the act of tightening and this one what follows it, so its endpoint is this paper's starting point: one bolt, seen over two different intervals of time.

4. The Separator

Observation 4.1

the separator is whether the members are still in compression.While compression remains, the load divides as ϕ and $1-\phi$——once they separate the bolt takes the whole of it, jumping from ϕ to 1 without passing through anything between.

Observation 4.2

so the formula differs on either side of separation.At 37384.7894 N the bolt's share goes from 0.197535 to 1——a jump of 5.06-fold. Separation is dangerous precisely because everything beyond it acts at once.

Observation 4.3

the contribution vanishes the other way from Paper 550.There the unselected stage contributed exactly zero——here the inconspicuous side carries the majority. Both are of the form "what decides is the arrangement, not the parts", but overlooking something that does nothing differs from overlooking something that does nearly everything.

Observation 4.4

separate roots under Paper 300."The load divides by stiffness" carries two elastic elements in series——"separation needs more than the preload" adds a preload to that. With no preload the first holds and the second vanishes.

Observation 4.5

what is not said.Tightening is not called safe——more preload delays separation and leaves the bolt less margin of its own. The two point opposite ways.

5. Roll Call and Closing

1. **bolt stiffness 2.987000×10^{8} N/m** (Computation 2.1): **EA_s/L.**
2. **ϕ from 0.084509 to 0.371379** (Computation 2.1): **a factor of 4.394554.**
3. **the bolt stays below half throughout** (Observation 2.3): **the core.**
4. **0.197535 at twice the diameter** (Computation 2.1): **within 0.005 of 0.2.**
5. **bolt 1975.3460 N, members 8024.6540 N** (Computation 3.1): **a ratio of 4.062404.**
6. **they sum back to the load** (Observation 3.2): **to 12 digits.**
7. **separating load 37384.7894 N** (Computation 3.4): **1.246160 of the preload.**
8. **fed back, compression is zero** (Observation 3.6): **the inversion checks.**
9. **the preload's origin belongs to Paper 463** (Observation 3.7): **its endpoint is this starting point.**
10. **the separator is remaining compression** (Observation 4.1): **separation jumps ϕ to 1.**

Closing: **When an external load pulls on a bolted joint, the bolt is taken to carry it.Yet the load divides by stiffness, and the majority falls on the clamped members——an external load of 10000 N on an M10 bolt over a 40 mm grip raises the bolt tension by only 1975.3460 N, the remaining 8024.6540 N being taken up as the members decompress, a ratio of 4.062404. The two sum back to the load to 12 digits, so this is a division and nothing disappears. The bolt is long and slender while the plates are short and broad, so k_m exceeds k_b, and the stiffer party takes the larger share.And this conclusion survives a badly uncertain assumption——the compression actually spreads as a frustum, so member stiffness cannot be pinned down; swinging the cylinder's outer diameter from 1.5 to 3.0 times the bolt diameter moved the bolt's share from 0.084509 to 0.371379, a factor of 4.394554. In all four it stayed below half: where a number cannot be trusted, an inequality still can. One of them, 0.197535 at twice the diameter, falls within 0.005 of the customary 0.2, which is a comparison with a value fixed outside this work.Separation, too, needs more than the preload——a joint preloaded to 30000 N holds to 37384.7894 N, 1.246160 times as much, because the bolt absorbs part of the load and leaves room before the compression reaches zero. Feeding that load back brings the compression to exactly zero. Where that preload came from is not asked here: how much of a wrench's torque arrives as axial force was already measured in Paper 463, at 11.61 per cent of the 718.0783-fold that geometry promises. That paper concerns the act of tightening and this one what follows it, so its endpoint is this paper's starting point.The separator is whether the members are still in compression——while compression remains the load divides as ϕ and $1-\phi$, and once they separate the bolt takes the whole of it, jumping at 37384.7894 N from 0.197535 to 1, a factor of 5.06 with nothing in between. Separation is dangerous precisely because everything beyond it acts at once. Under Paper 300, "the load divides by stiffness" carries two elastic elements in series while "separation needs more than the preload" adds a preload: with no preload the first holds and the second vanishes.Placed among the earlier papers——it is the shape of Paper 477, since the bolt may be thickened while the members carry eight tenths of the load, though that paper concerns the location of a limit and this one a division that can itself change. Against Paper 550 the contribution vanishes the other way: there the unselected stage contributed exactly nothing, while here the inconspicuous side carries the majority. Overlooking**

something that does nothing differs from overlooking something that does nearly everything.To be honest——no design is recommended; what preload to choose was not stated. Member stiffness was approximated by a cylinder, which is exactly why the values were not relied on and the assumption was swung instead. Only the elastic range was treated, with yielding, thread shear and embedding relaxation excluded, and loosening and cyclic loading left aside. The relation between tightening torque and preload was not computed either: that belongs to Paper 463, and this paper begins where the preload is given. Nor is tightening called safe: more preload delays separation and leaves the bolt less margin of its own.

References

1. Bickford, J. H. (2008). *Introduction to the Design and Behavior of Bolted Joints* (4th ed.). CRC Press.
2. Budynas, R. G., & Nisbett, J. K. (2015). *Shigley's Mechanical Engineering Design* (10th ed.). McGraw-Hill.
3. VDI 2230 Part 1 (2015). *Systematic Calculation of Highly Stressed Bolted Joints*. Verein Deutscher Ingenieure.
4. Yamagishi, Y. (2026). *The Three Hundredth Census: Whether Two Things Share a Root Is Decidable* [Paper 300]. Zenodo. 10.5281/zenodo.22171914
5. Yamagishi, Y. (2026). *Of the Seven Hundredfold Geometry Promises, One Tenth Arrives* [Paper 463]. Zenodo. 10.5281/zenodo.22733205
6. Yamagishi, Y. (2026). *While the Wrong Input Is Being Added, the Limit Is Somewhere Else* [Paper 477]. Zenodo. 10.5281/zenodo.22733686
7. Yamagishi, Y. (2026). *Widening Helps Either Fully or Not at All, With Nothing In Between* [Paper 550]. Zenodo. 10.5281/zenodo.23014187

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Yuuki YAMAGISHI (山岸 勇輝)

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