

Load take-down analysis in structural FEM software

This CPD module, sponsored by SCIA, introduces best-practice guidelines for load take-down (LTD) analysis – the determination of how vertical loads accumulate and travel down through a building to its foundations. It explains when a simple tributary-area approach is sufficient, when a full finite element approach is required, and how the dedicated LTD capability introduced in SCIA Engineer V2027 bridges the two.

Continuing professional development (CPD) ensures you remain competent in your profession. Chartered, Associate and Technician members of the Institution must complete a specified amount each year. All CPD undertaken must be reported to the Institution annually. Reading and reflecting on this article by correctly answering the questions at the end is advocated to be:



1 hour of verifiable CPD

Every structural design ultimately answers a deceptively simple question: how much load arrives at each column, each wall and each footing? Getting that answer right governs member sizing, foundation design and, increasingly, the cost and carbon of a project. Yet as buildings become taller and more irregular, the path that load follows from roof to ground is rarely obvious.

Load take-down (LTD) is the process of summing permanent, imposed, snow and other gravity actions storey by storey and tracing them through the loadbearing structure to the foundations. Traditionally performed by hand or in a spreadsheet using tributary areas, it remains one of the most common verification tasks in any practice – and one of the easiest to get subtly wrong when the structure stops behaving like a stack of simply supported elements.

Why load take-down matters

LTD results (**Figure 1**) feed directly into three downstream activities: foundation design (axial loads and, where relevant, base moments at each support point), vertical member design (the accumulated axial force in columns and walls), and transfer-structure design (where load changes path through beams, walls or trusses). An error introduced high in the building propagates all the way to the foundations, so confidence in the take-down is confidence in the whole gravity system.

LTD is also a primary communication

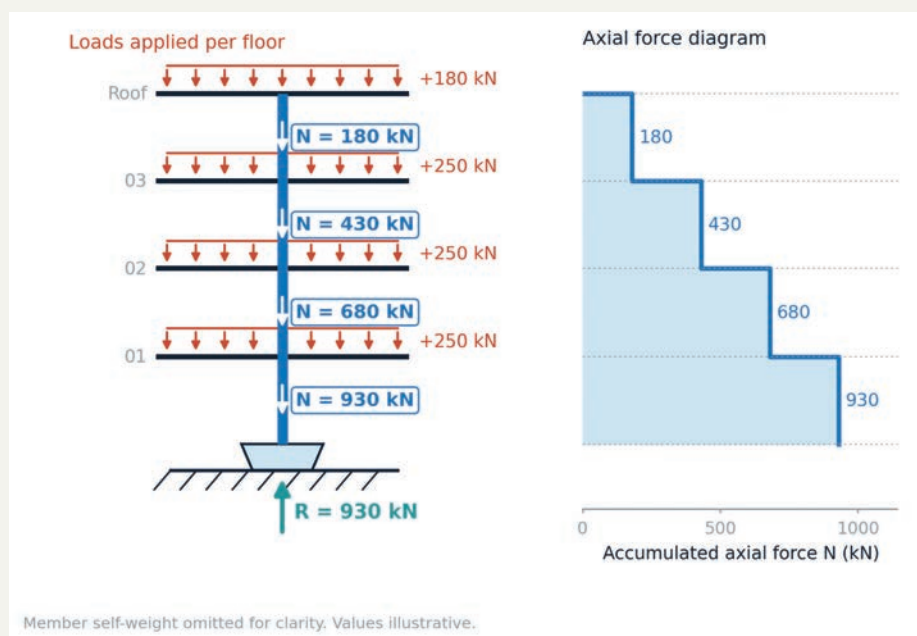


FIGURE 1: Accumulation of axial force down a single column line. Each floor adds its tributary share to the running total

tool. Reactions at the base are what the geotechnical engineer needs; column loads are what the connection designer and the contractor pricing the frame want to see. A clear, auditable take-down is therefore as much a deliverable as it is an analysis step.

Tributary area vs FEM load paths

The classic hand method assigns to each vertical element the load from the floor area it is assumed to support – its tributary (or influence) area. For an orthogonal grid of one-way or two-way slabs on regularly spaced columns,

tributary areas give fast, transparent and perfectly adequate results.

The method breaks down when stiffness, not geometry, decides where load goes. Continuous slabs redistribute load toward stiffer supports; deep transfer beams hang load from points far from the tributary boundary; differing column stiffnesses attract unequal shares of a shared slab. In all of these, the real load path follows relative stiffness, which generally needs a finite element model (FEM) to be correctly captured (**Figure 2**).

Building cores: a stiffness-driven special case

Lift and stair cores are the clearest illustration of why stiffness, not tributary geometry, governs load path. As reinforced concrete walls running the full height of the building, cores are typically far stiffer axially and flexurally than the columns around them – so an FEM model routinely pulls in floor load from well beyond the core's nominal tributary boundary, particularly on flat slabs and transfer floors. Hand tributary methods, which assign load purely by adjacent floor area, systematically understate this. Cores also accumulate substantial self-weight from the walls themselves over many storeys, which a take-down must track separately from the redistributed slab load. Because core geometry – wall thickness, openings, coupling beams – often changes floor to floor, per-storey reporting is not optional here; it is the only way to catch a stiffness change that silently alters the load split below it.

The reaction-to-load problem in 3D models

If modelled correctly, a full 3D FEM model gives accurate support reactions, so it might seem that LTD is solved automatically. The difficulty is that a global model returns a reaction at the base of each element but does not, by itself, tell the engineer how much of that reaction originated on each individual floor, nor how load split between parallel paths on the way down.

Engineers frequently need the storey-by-storey contribution – for example, to check a column at an intermediate level, to verify a transfer beam, or to provide a geotechnical engineer with a breakdown of permanent versus imposed load at a footing. Extracting that information from raw reactions is tedious and error-prone, which is precisely the gap a dedicated LTD tool fills.

Load paths and transfer structures

Where a column or wall does not run continuously to the foundation, its load must transfer horizontally through a beam, a wall acting as a deep beam, or a truss before continuing down (**Figure 3**). Transfer levels are the highest-risk points in any take-down:

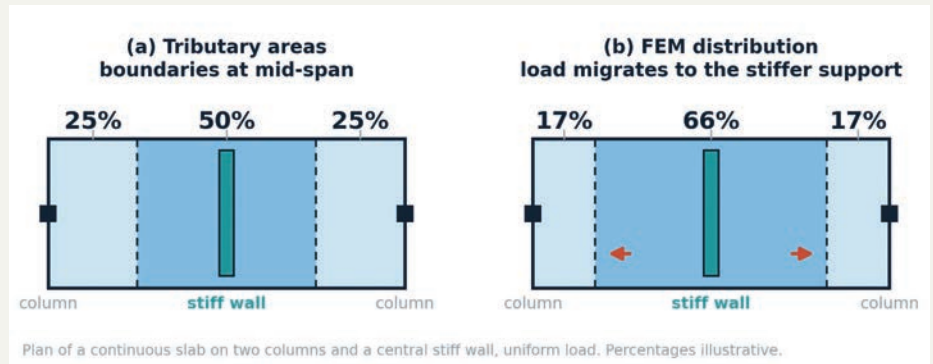


FIGURE 2: For irregular grids and stiff/flexible support combinations, tributary areas (left) and the true FEM distribution (right) can differ markedly

a small modelling error multiplies because the transferred load is large and concentrated

- | Confirm that the transfer element is stiff enough that the assumed load path is realistic; a flexible transfer beam may shed load back to adjacent stiffer paths.
- | Check both the element receiving the load and the elements it hands off to – force that disappears from one path must reappear in another.
- | Treat the transfer reaction as a design action in its own right, with permanent and variable parts kept separate for combination.

One-way vs two-way load distribution

Before any load can be taken down, it must first be decided which way it goes. The spanning behaviour of each floor governs which beams, walls and columns collect its load, and a wrong assumption here sends

load down the wrong path from the very top of the building.

A one-way slab – long and narrow, or detailed to span in a single direction – delivers essentially all its load to the two supports it spans between, and almost none to the edges parallel to the span. A two-way slab, square or close to it, shares its load between all four edges in proportions that depend on the aspect ratio. The classic tributary shapes follow directly: rectangular strips for one-way action, and the familiar triangles and trapezoids for two-way action. Get the spanning direction wrong and the tributary areas – and therefore every load further down that path – are wrong with it.

The distinction matters most where it is least obvious. A slab that the designer intends to span one way may, once modelled as a finite element plate, distribute load in two directions according to its real stiffness, quietly loading

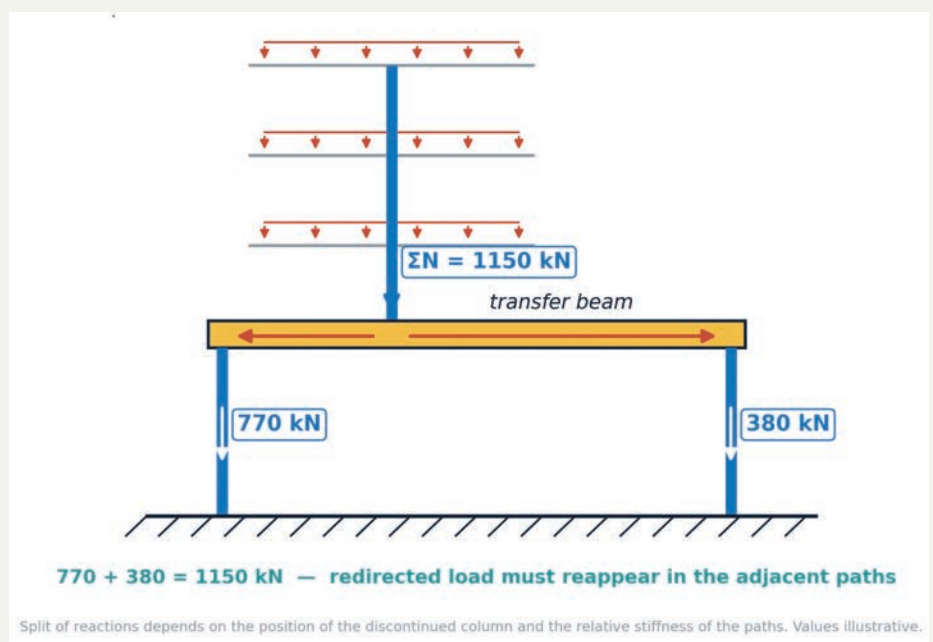


FIGURE 3: A discontinuous column transfers its accumulated load through a beam to adjacent supports. The take-down must follow the redirected path

supports that the hand calculation assumed carried nothing. Conversely, forcing a genuinely two-way slab into a one-way assumption can overload the spanning supports and leave the others unconservatively light.

For the take-down, this has a practical consequence: the load path assumed for distribution must be consistent with how the slab is actually modelled and reinforced. Where the two disagree, the total reactions can still balance the applied load while individual supports receive the wrong share, so the warning sign is the distribution between supports rather than the global total.

Common pitfalls

-) **Double counting at shared supports** – the same area assigned to two elements, inflating total load above the applied load. *How to catch it:* the sum of base reactions exceeds the total applied gravity load, or a storey's contribution to a shared support jumps in a way the tributary geometry doesn't explain.
-) **Lost load** – the sum of base reactions failing to equal the total applied gravity load. *How to catch it:* reconcile the two for a single unfactored load case, then isolate the take-down storey by storey to find where the shortfall first appears, and inspect the load assignments, connectivity and traced load path at that level.
-) **Ignoring self-weight of vertical members**, which can be significant in tall concrete structures. *How to catch it:* compare each storey increment against the member volume multiplied by its unit weight, or inspect a self-weight-only case and confirm that a column still gains load between levels where no floor load is applied above.
-) **Mishandling imposed-load reduction**. Codes permit a reduction in imposed load on columns and foundations supporting several storeys, on the statistical basis that all floors are unlikely to be fully loaded at once. A take-down that does not keep the number of contributing storeys visible cannot apply this reduction correctly – applying it inconsistently between the column and foundation checks, or omitting it, may significantly oversize lower columns and footings. *How to catch it:* compare the number of contributing storeys used at each level against the code's reduction table, and confirm the column check and the footing check below it use the same storey count – a mismatch between the two is the most common sign of inconsistent application.
-) **Mixing characteristic and design values**, so that factored loads are inadvertently factored again. *How to catch it:* back-calculate – divide the reported total by the partial factor you expect was applied; if a nominally 'characteristic' total already looks pre-factored, or the design total is high by roughly a partial-safety-

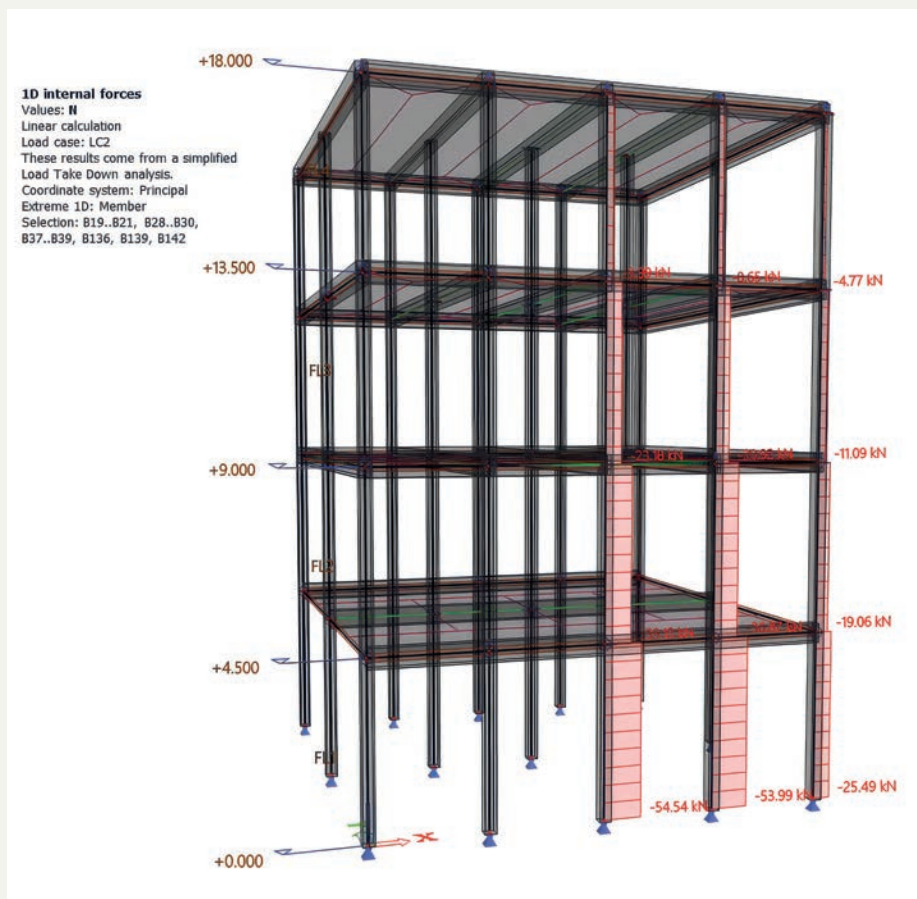


FIGURE 4: Load take-down analysis in SCIA ENGINEER – accumulation of axial force through the columns to the supports

factor multiple against a quick characteristic hand estimate, values have been mixed somewhere in the chain.

Verifying a load take-down

An LTD – whether by hand or by model – is only as trustworthy as the checks run against it, and those checks fall into two distinct kinds that should not be judged against the same tolerance.

The first is a global equilibrium check: does the sum of every base reaction equal the total applied gravity load? This is a bookkeeping check on the take-down's own internal consistency, not a check of whether its assumptions are realistic. It should close almost exactly, and even a small unexplained residual is worth investigating rather than dismissing, since at this level a gap almost always traces to a specific, findable error: a missing load case, an unconnected node, a load applied at the wrong storey, or an element excluded from the traced path.

Because it compares the take-down against the model's own applied load, it cannot reveal a load that was specified wrongly in the first place; that requires a permanent and imposed load total built independently from the drawings and the loading specification, kept separate

by action and compared on an unfactored, unreduced basis.

The second is a plausibility check against an independent estimate – typically a quick tributary hand calculation for a handful of representative elements: one on a regular grid, one adjacent to a core, one below a transfer. Here, disagreement is expected rather than alarming, particularly near cores and transfer structures, because the model-based take-down exists precisely to capture the stiffness-driven redistribution a tributary estimate cannot.

No single percentage separates an acceptable difference from a worrying one, so judge each discrepancy against the accuracy expected of the check and its consequence for the design. On a regular grid, a few per cent is noise. Near a core or below a transfer, differences of tens of per cent are normal, because the model captures redistribution that a tributary estimate cannot.

A difference approaching a factor, however, still has to be explained by a stiffness effect that can be identified. Load attracted toward a core or a transfer element is consistent with how stiffer elements behave, but less load than the tributary estimate can be equally legitimate, where a flexible transfer beam sheds load, a cracked core loses stiffness, or hanging action intervenes.

The questions that matter are whether the difference is explained by the modelled stiffness, and whether it changes a member size or a foundation decision; where it does, test mesh density, cracked versus uncracked stiffness and support fixity before relying on the result.

Load take-down in SCIA Engineer V2027

SCIA Engineer V2027 introduces a dedicated LTD capability that works directly on the analysis model rather than as a separate spreadsheet exercise. It traces gravity actions through the modelled load path and reports, for any selected column, wall or support, the accumulated load (**Figure 4**).

Because it reads the same geometrical model used for analysis and design, the take-down stays consistent with the structure as it evolves – when a grid, slab thickness or support changes, the take-down updates with it. Results can be presented per storey for transparency, and the totals reconcile against the global applied load so that lost or double-counted load is caught immediately.

However, although the LTD runs its own numerical model, built specifically to trace gravity load through the structure, the take-down inherits the sensitivities of a classic FEM

model. For walls, mesh density affects how load concentrates near supports, openings and re-entrant corners; the choice between cracked and uncracked stiffness changes how load redistributes between competing paths, since cracking lowers a member's flexural stiffness and can shift load toward stiffer, less-cracked members; and the fixity assumed at each support – pinned, fixed, or a rotational spring – governs how much moment, and therefore how much of the reaction, that support is asked to carry.

These are not unique to a dedicated LTD tool; they are the same assumptions that govern any FEM analysis. But because a take-down presents a single load figure per support, it is easy to forget that the figure reflects one particular stiffness distribution and one designer's modelling choices, not a value independent of them.

Conclusion

LTD is a foundational verification that sits between analysis and foundation design. Tributary-area methods remain valuable for regular structures and for sanity-checking, but as soon as stiffness governs the load path – irregular grids, transfer structures, mixed support stiffnesses – a model-based take-down is required. Whichever method is used,

the engineer must keep actions separated, track contributing storeys for imposed-load reduction, and always reconcile base reactions against applied load.

A dedicated, model-integrated tool such as the LTD capability in SCIA Engineer V2027 removes the manual bookkeeping while preserving the transparency that makes a take-down trustworthy. As with any software result, however, understanding the underlying assumptions remains the engineer's responsibility.

Final note

Guidance on actions, combinations and imposed-load reduction relevant to LTD can be found in the following publications:

→| British Standards Institution (2002) *BS EN 1990:2002 Eurocode. Basis of structural design*, London: BSI

→| British Standards Institution (2002) *BS EN 1991-1-1:2002 Eurocode 1. Actions on structures - General actions - Densities, self-weight, imposed loads for buildings*, London: BSI

→| Parker J. (2026) 'Technical Guidance Note (Level 2, No. 28): Introduction to construction sequence modelling', *The Structural Engineer*, 104 (7), pp. 16–19; <https://doi.org/10.56330/MMKB9162>

Questions

To claim your CPD certificate, answer the questions online at www.istructe.org/industry-cpd. This module will close on 30 November 2026.



1) What is the main limitation of the tributary-area method for load take-down?

- a) It cannot handle permanent loads
- b) It assumes the load path follows geometry rather than relative stiffness
- c) It cannot be used for steel structures
- d) It always overestimates foundation loads

2) When is a finite element/model-based load take-down preferable to tributary areas? (Select all that apply.)

- a) Irregular column grids
- b) Slabs supported on columns of differing stiffness
- c) Structures with transfer beams or transfer walls
- d) A perfectly regular orthogonal grid of identical columns

3) Why does a slab's spanning direction (one-way vs two-way) matter for a load take-down?

- a) It determines which supports collect the

load, and so the tributary areas and every load further down that path

- b) Spanning direction only affects deflection, not how load is distributed
- c) A two-way slab always delivers all its load to a single pair of supports
- d) Spanning direction is only relevant for steel decks, not concrete slabs

4) Why are transfer levels the highest-risk points in a take-down?

- a) Because they carry no load
- b) Because a modelling error there involves large, concentrated redirected loads
- c) Because they are always at roof level
- d) Because tributary areas are easiest there

5) What advantage does a model-integrated load take-down (as in SCIA Engineer V2027) offer over a separate spreadsheet?

- a) It eliminates the need to define load cases
- b) It removes the need to design foundations
- c) It automatically selects the behaviour factor

d) It stays consistent with the model as the structure changes and reports load per storey by load group

6) In which situation will tributary-area and true FEM load distribution differ most?

- a) A single simply supported beam
- b) A regular grid of identical columns under uniform load
- c) A continuous slab on supports of markedly different stiffness
- d) A statically determinate truss

Supplied and sponsored by



SCIA
BY ALLPLAN