



[56 Leonard Street, New York.]

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[26th March 2026]

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Original Design

56 Leonard street was designed by Herzog & de Meuron with the structural engineering being conducted by WSP. The 57-story residential building is in the Tribeca neighbourhood of Manhattan, New York. The outstanding architectural premise treats individual rooms as protruding "pixels," resulting in a highly asymmetrical concrete frame featuring chaotic, overlapping cantilevers that extend up to 25 feet.

Cantilevers

The building features massive, irregular concrete overhangs ranging from 10 to 25 feet, creating its signature "Jenga" appearance (www.architecturalrecord.com, n.d.). Because of this design the central balance will be moved with every cantilever added. The engineer and architect would need to counteract this when applying the next cantilever on the opposite side on the floor above. This could be done by either adding the same length and weight cantilever on the floor above or by adding multiple cantilevers over multiple floors. By adding the cantilevers on the opposing side this brings the central balance back to the centre of the building (Massey, 2021).

Walking Columns

Because the floor plates shift continuously, the vertical columns do not align perfectly from the ground to the roof. The design relies on "walking columns" one to two-story structural walls that shift locations floor-by-floor, transferring loads diagonally and vertically down the structure (www.architecturalrecord.com, n.d.).

Central Core and Outriggers

A heavily reinforced central concrete core provides the main lateral stability to fight against wind and seismic forces. This core is tied to the exterior perimeter columns via massive structural outriggers and belt walls located at mechanical levels 32 and 46 (www.architecturalrecord.com, n.d.).

Slosh Damper

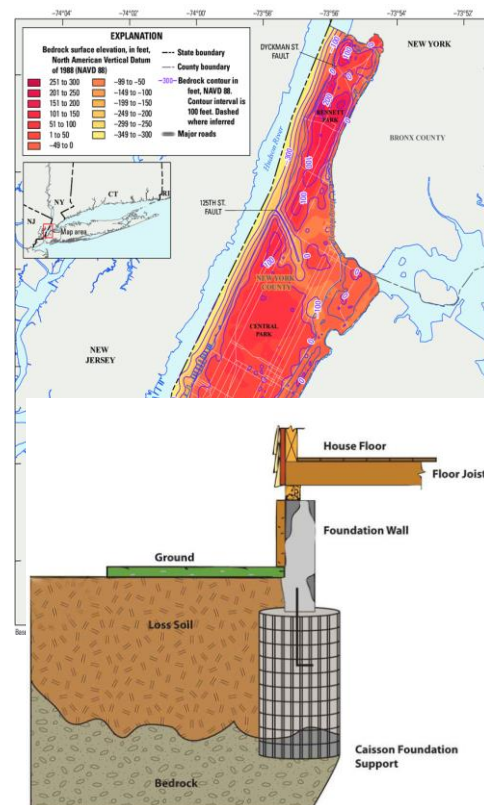
To temper the building's movement in the wind, a 130,000-liter water slosh damper is located at the top of the building. This helps counter wind and earthquakes this is because as the building moves to the right the water moves to the left and when the building moves to the left the water moves to the right. This helps to keep the buildings center of gravity centered by distributing weight to the opposing side (How did they build that? 2021 00:16:30).

Methods of construction

To understand the construction method, a geotechnical appraisal of the site is mandatory. Unlike Midtown or Lower Manhattan where the rock strata is close to the surface Tribeca sits in a geological "bedrock valley." (USGS 2023). Here, the highly competent bedrock dips to

depths exceeding 40 meters, buried beneath layers of wet, viscous subsoil and glacial till. The primary geotechnical risk at this site was differential settlement. The building's extreme asymmetrical cantilevers generate immense eccentric loads and overturning moments (WSP, 2025). If standard shallow foundations were placed in the compressible glacial till, the uneven weight distribution would cause the building to lean or shear catastrophically.

To mitigate this risk, WSP engineered a deep foundation system. Massive reinforced concrete caissons (drilled shafts) had to be excavated through the wet subsoil and socketed directly into the deep Manhattan Schist (USGS 2023). Above ground, the building relies on a cast-in-place concrete central core for lateral stability, paired with "walking columns" perimeter columns that physically shift locations floor-by-floor to transfer the eccentric loads diagonally down to the deep foundations (www.architecturalrecord.com, n.d.).



The framing material's strength, durability, and climatic resistance

- **Compressive Strength:** The extreme asymmetrical cantilevers (ranging from 10 to 25 feet) generate massive overturning moments (WSP, 2025). To safely transfer these eccentric loads down to the foundations, the structural design relies on a system of "walking columns" structural walls that shift locations from floor to floor. Because of the immense pressure this creates, the lower-level columns required ultra-high-strength concrete of 12,000 psi, which was gradually reduced to 7,000 psi at the higher, lighter levels of the tower (willis, carol 2026).
- **Durability and Climatic Resistance:** The architectural design leaves the horizontal concrete floor slabs fully exposed to New York's aggressive freeze-thaw cycles. Because concrete is porous, freezing water expands and causes structural spalling. To mitigate this severe climatic risk, exterior architectural concrete of this type relies on air-entraining agents, which introduce microscopic air voids into the mixture to allow freezing water to expand safely without damaging the structural matrix (Neville, 2011).

Time, Labour, Programme, and Cost (Compared to Steel Framing)

- **Cost and Spatial Efficiency:** In the highly regulated New York City real estate market, flat-plate concrete construction allows for thinner structural floor depths compared to deep steel I-beams. As noted in CTBUH studies on New York's super-slender towers, minimizing floor-to-floor height allows developers to maximize the number of sellable floors within strict zoning limits, validating the "logic of luxury" and increasing profitability (Willis, 2014).
- **Programme and Labour Risks:** The trade-off was a severe impact on time. Because 56 Leonard's floor plates constantly shift, standard "jump" formwork could not be repeated. As architectural critics noted, no two consecutive floors are the same, turning the building into a "monumental sculpture" that required intense, bespoke on-site labor to construct (www.architecturalrecord.com, n.d.).

Assembly, Adaptation, and Life Cycle

- **Ease of Assembly:** The assembly of the frame was exceptionally difficult. For the largest cantilevers, engineers had to cast hidden concrete "Vierendeel trusses" perpendicular columns that engage two floors simultaneously to support the weight without blocking the glass views (WSP, 2025).
- **Life Cycle Adaptation:** Despite the arduous assembly, the resulting concrete frame offers exceptional adaptability. Because lateral stability is managed entirely by the robust central core and perimeter walking columns, the residential apartments contain "no dividing shear walls... at all" (WSP, 2025). This allows residents to easily demolish internal partitions to reconfigure their layouts over the building's lifecycle.

Integration of Services Provision

Integrating mechanical services presents a distinct challenge in concrete flat-plate buildings, which lack the natural ceiling cavities found within steel frameworks.

- **Overcoming the Problem:** To route horizontal drainage without compromising ceiling heights, engineers utilized highly coordinated "slab depressions" localized zones where the concrete floor slab is cast at a lower elevation. Furthermore, to address the building's tendency to sway in the wind, engineers integrated a massive mechanical service at the very top of the building: a 130,000-liter water slosh damper designed to counteract wind-induced acceleration (www.architecturalrecord.com, n.d.).

End-of-Life Demolition Challenges

The eventual demolition of 56 Leonard Street will present severe structural hazards.

- **Progressive Collapse Risk:** The building's structural integrity relies on the delicate balance of its walking columns and outriggers. Because the loads are transferred

diagonally, removing a structural element out of sequence during demolition could unpredictably alter the load paths. Explosive demolition would not be possible in the dense Tribeca neighborhood therefore, breaking down the 12,000-psi concrete and separating it from the dense rebar cages will be highly energy-intensive and financially burdensome.

The negative impact of the concrete production process.

Community Impacts: The production and transportation of concrete severely disrupt local communities. For an urban project, thousands of heavy concrete mixer trucks must navigate narrow streets, causing traffic congestion, noise pollution, and degradation of local air quality due to diesel emissions. Further up the supply chain, the extraction of raw materials impacts communities located near quarries through heavy machinery noise and airborne silica dust, which is a respiratory hazard (How did they build that? 2021)

Environmental Impacts: Concrete's primary binding agent is cement, and the global cement manufacturing industry is responsible for approximately 8% of all global carbon dioxide (CO₂) emissions (World Economic Forum, 2024)

- **Calcination:** This massive carbon footprint is largely due to "calcination" a chemical reaction that occurs when limestone (CaCO₃) is superheated in kilns to produce clinker. This process causes the limestone to decompose, releasing massive amounts of trapped CO₂ directly into the atmosphere (World Economic Forum, 2024).
- **Resource Depletion:** Concrete production is incredibly water-intensive and relies heavily on the aggressive dredging of riverbeds and coastlines for construction-grade virgin sand. This dredging devastates aquatic ecosystems, disrupts local hydrology, and accelerates coastal erosion.

Sieve analysis

Sample 1250g

Sieve size (mm)	Mass (g)	% on sieve	% Passing
125	0	0	100
75	0	0	100
63	0	0	100
37.5	120	9.6	90.4
20	137	10.96	79.44
10	143	11.44	68
6.3	105	8.4	59.6
3.35	45	3.6	56
2	130	10.4	45.6
1.18	63	5.04	40.56
0.6	105	8.4	32.16
0.3	102	8.16	24
0.212	109	8.72	15.28
0.15	98	7.84	7.44
0.063	55	4.4	3.04

Fine against coarse aggregate.

Original sample mass = 1250g

Mass retained on 5 mm and larger sieves.

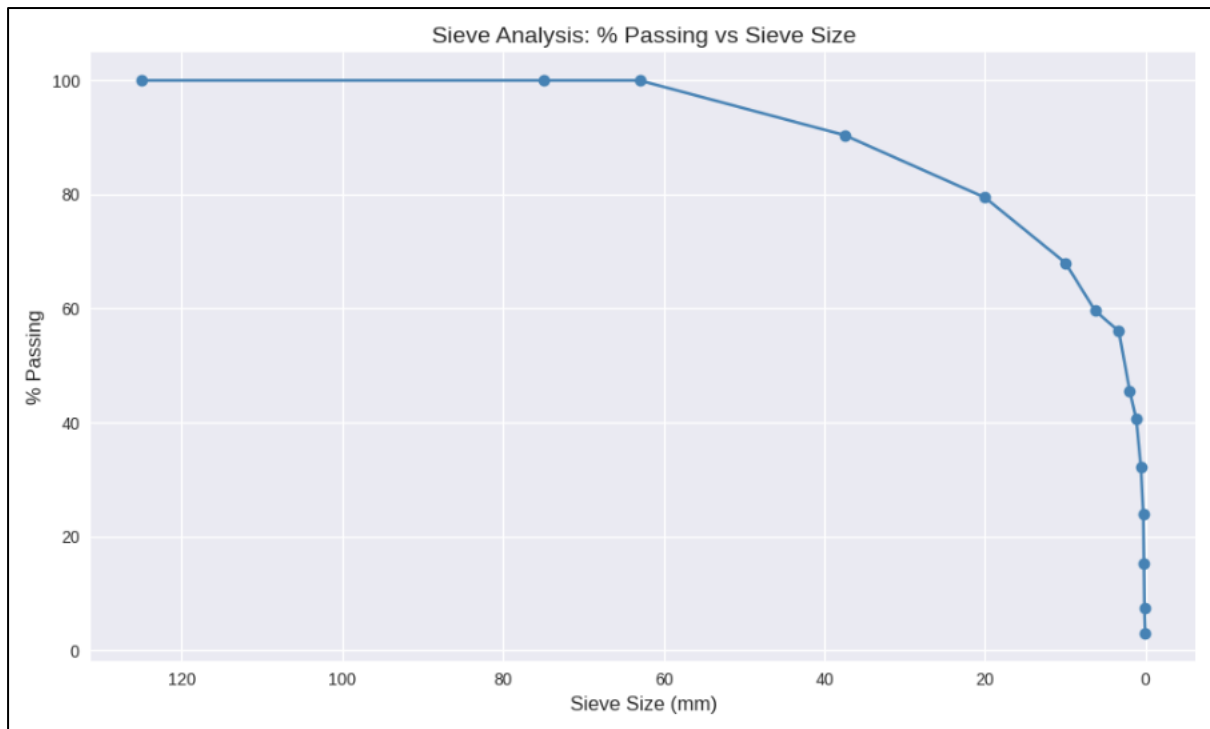
- 75 mm = 0g
- 63 mm = 0g
- 37.5 mm = 120g
- 20 mm = 137g
- 10 mm = 143g
- 5 mm = 55g

This means the total coarse aggregate mass = 455g

% Coarse aggregate $(455-1250 \times 100) = 36.4\%$

Fine aggregate mass = original mass – coarse aggregate mass = 795g

% of Fine aggregate $(795-1250 \times 100) = 63.6\%$



Particle Size Distribution and Suitability for Direct Use.

The all-in aggregate is heavily skewed toward the finer fractions. Looking at the data from the completed table, material was retained on almost every sieve from the 37.5mm down to the pan. This indicates a wide, uninterrupted range of particle sizes rather than a single-sized or gap-graded material.

Crucially, my calculations using a 5mm boundary reveals that the mix consists of 63.6% fine aggregate and only 36.4% coarse aggregate. While the very fine silt and clay content (material passing the 0.063mm sieve) is acceptably low at just 3.04%, the overall dominance of sand-sized particles defines the character of this sample.

Regarding its suitability for direct use meaning using the aggregate exactly as it was sampled without further processing the applications are quite limited. Because it is an all-in aggregate it is generally only suitable for low-grade, non-structural applications. Examples of acceptable direct use would include, basic trench fill, or light domestic footings where precise compressive strength and strict quality control are not critical.

However, I would highly recommend against using this sample directly for structural or high-strength concrete for several reasons. Primarily, the disproportionately high fine aggregate content (63.6%) creates a massive total surface area within the mix. To make a concrete mix workable with this much sand, a significantly higher volume of water would be required. Increasing the water content naturally weakens the concrete and increases the risk of shrinkage and cracking. To counteract this weakness and maintain the target strength, we would be forced to add much more cement, rendering the mix highly uneconomical.

Furthermore, standard industry practice dictates that structural concrete requires strict quality control. Relying on an unpredictable, natural all-in mix does not provide the consistency needed. Best practice requires aggregates to be washed, screened into distinct size fractions (such as 20mm, 10mm, and fine sand), and then precisely weighed and recombined during batching to achieve an optimized, reliable mix design.

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