

TABS (Termaly activated building structures)

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The lecture focuses on ceiling-wide TABS systems, which deliver high comfort without drafts or noise, with very low supply temperatures (~30 °C for heating, 18–22 °C for cooling) and substantial thermal storage. The principle is plastic pipes embedded in reinforced concrete slabs that “activate” the mass; radiant exchange + thermal capacity → stable operative temperature. The lecture covers application forms—mainly for new builds; the need for integrated planning (pipe spacing 15–20 cm, routing that avoids later drilling, limit full suspended ceilings), good performance in prefabrication, and it highlights very low energy use and maintenance. Ideally combined with shallow geothermal and photovoltaics, TABS allow low-cost “storage” of energy in the structure and increase buildings’ climate resilience.

.SUMMARY

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Motivation

- Comfort and health: radiant ceilings without drafts, less dust movement, no air overdrying; suitable for sensitive users and allergy sufferers.
 - Energy efficiency: low supply temperatures (≈ 30 °C heating, 18–20 °C cooling) vs. high-temperature radiators/AC.
 - Space and aesthetics: clean interiors without visible units/cassettes.
 - References and tradition: historical examples (STU, LD Helios) prove long-term viability of the concept.
 - Low operating costs: minimal service compared to AC/fan-coils.
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Principle of operation

- Radiation vs. convection: the concrete mass with embedded pipes delivers heat/coolth by radiation → higher operative temperature and a stable thermal sensation.
- Storage and stability: the high thermal capacity of the core smooths peaks; the “church effect.”
- Full ceiling area: 100% active surface → higher output, especially in small rooms (compared to floors).
- Limits and design: do not cover with plasterboard; only partial/metal ceilings are acceptable; the system runs continuously with a longer response time.
- Maintenance and safety: closed hydronic loop with no dust; drilling damage is repairable; recyclability of today’s structures is manageable.

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Application in practice

- Integrated planning: MEP enters the design early; coordination of manifolds, routes, and no-drill zones for critical areas.
- Implementation variants: pipes above/below bottom reinforcement; filigree/prefab panels; choose per required output, response, and installation economics.
- Distribution density: optimize spacing ($\approx 15\text{--}20\text{ cm}$); denser spacing = little benefit for substantially higher cost.
- Operation and control: simple, reliable controls (ideally without “display temptation”), weather compensation; option for predictive control (AI).
- Renovation limits: TABS are primarily for new builds; in retrofits use plastered-in ceiling/wall radiant systems.

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Adaptation to climate change

- Low temperature lifts: efficient with low-temperature sources (heat pumps, ground heat exchangers).
- Energy districts/PED: suitable for positive/renewed districts with local heat/cool sources.
- Building as a “battery”: inexpensive, ecological storage of solar energy in concrete (higher kWh/€ than water tanks or batteries).
- Healthy indoor environment during heatwaves: comfort even at $24\text{--}26\text{ °C}$ without drafts or thermal shocks (recommended $\Delta T \leq 6\text{ °C}$).
- Resilience and operational reliability: minimal service, long life, less dependence on maintenance personnel and refrigerants.

.TRANSCRIPTION OF THE RECORDING

MOTIVATION

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Hi Miro, today I'd like to talk about TABS—Thermally Activated Building Structures, or in German BKT. These are systems used for heating and cooling buildings.

Motivation—why should an architect, designer, or developer work with these systems? The key point is they are ceiling-wide radiant systems that are highly energy-efficient. Mainly because they deliver high comfort, no air movement, large thermal storage capacity, and an exceptional ability to work with very low supply temperatures—around thirty degrees Celsius for heating—unlike radiators, which traditionally ran at fifty, seventy, even ninety degrees Celsius. And for cooling, compared with AC where ~ 8 °C water is used on coils or fan-coils, here we send 18–20 °C water into the slabs. That's where the comfort and health benefits come from—minimal movement of either warm or cold air.

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Warm-air systems tend to overdry the air, lowering indoor relative humidity; cooling with air has the health downside that it blows on you. For example, you come into a space sweating and there's a device—fan-coil or AC—blowing 8 °C air at you. When you talk about air movement, you're comparing with devices that heat or cool air—i.e., air-based systems? Or even with radiators? Radiators too. With high surface temperatures they drive... a lot of air movement. We used to see curtains moving near windows—that's convection, not radiation. We'll explain that later. TABS are used in apartment buildings too. Historically this started in German-speaking countries in offices—open-plan spaces—where the concrete structure was used as an active element for heating and cooling.

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Over years of implementation we have come into the residential sector. A very good domestic example is an old faculty building of the Slovak University of Technology in Bratislava (STU) using the Crital system—back in the 1970s—where the ceilings were used for heating. Another great reference known to our seasoned engineers is the Helios Sanatorium at Štrbské Pleso, designed for children with asthma from across former Czechoslovakia; even then they focused on health benefits. As today's plastics didn't exist, metal pipes were welded to reinforcement and the ceiling did the heating. So we are returning to what our predecessors implemented around 1970 in Czechoslovak buildings. And architects can design spatially clean, aesthetically pure interiors without visible HVAC units.

PRINCIPLE OF FUNCTION

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A for either heating or cooling. In air-based systems you need cassettes or units—color-matched or typically white—that become a visible part of the space. With TABS that disappears. How do these systems work? The key change is moving from convective air heating/cooling to radiant exchange. In other systems, air is the carrier of energy; in radiant systems the structure has a surface temperature that sets a higher and more pleasant operative temperature in the room. The concrete “sees” the walls, the table, the occupant—it radiates to them—so the space feels much more comfortable than when air blows on you from a diffuser, even if that diffuser is designed to keep air velocities in the comfort range (say 0.2 m/s at 22–26 °C).

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Still, in real offices you often see people covering diffusers with paper to redirect the jet. With TABS—or other ceiling radiant systems—the (illustrated) version here is a plastered-in system: a carrier pipe for the thermal medium, typically heating/cooling water, is fastened into or embedded within the concrete structure, transfers energy to it, and stores it there. The detailed execution is a matter for the MEP engineer, but there are several options. The foundation for success is, again, integrated planning: the MEP designer must join the project much earlier than with conventional radiator systems where the architect laid out the plan and the radiators “went under the window” as a late-stage add-on.

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With TABS, the MEP joins early. The core technical principle is storage and stability: the large mass of concrete is charged with energy—heat or coolth—creating steady conditions. Think of entering a large old church—St. Martin’s Cathedral, say—on a 35 °C day and feeling pleasantly cool; same idea: a massive structure carrying over a lot of energy from winter. Compared to other structures—and even to underfloor heating—one advantage is we have 100% of the ceiling area available. In our region ceilings are usually smooth and white—plastered or exposed concrete—so in an apartment or office you have the full ceiling area available. By contrast, in a small bedroom of, say, 12 m², the bed (4 m²) already removes a third of the usable floor area, plus a dresser, rug, etc.—underfloor heating there may be insufficient, and it cools poorly.

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Our priority is a healthy environment in both summer and winter; that’s what radiant ceilings deliver. The drawback—echoing what I said—is you mustn’t install continuous suspended ceilings under activated slabs. Only partial ceilings are possible, ideally metallic so they can pass energy onward.

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You cannot fully cover TABS with plasterboard; otherwise you must switch to gypsum radiant ceiling panels, which are typically four to five times more expensive than

TABS. Compared with standard AC, the thermal store is the concrete, and the heat-transfer medium is water. In AC, the medium is air, which has poorer physical properties for energy transfer; hence lower temperatures and longer runtimes. Another key point is service and maintenance. I'm not a categorical opponent of AC, but to maintain a healthy indoor environment, AC needs regular servicing: it draws in and blows out air, dust accumulates, and units must be cleaned and disinfected once or twice per year.

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Tempered concrete cores or ceiling radiant systems are embedded in the structure and are essentially maintenance-free. That's a major advantage vs. conventional systems—including fan-coils, which use a fan to blow warm or cold air even if the source is water. With direct-expansion AC the medium is a refrigerant; and here we encounter regulatory shifts—freons must be phased out, and modern lower-GWP refrigerants often have the downside of being flammable or mildly explosive. So we're moving toward hydronic systems for large residential complexes, with centralized heat/cool sources outside the building. In short:

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Comfort and health mean uniform temperature without drafts or dust movement—and silence. At night no fans whirring or air jets blowing. With AC you often get the opposite, plus the allergen risk if maintenance is neglected. Maintenance is a main driver of higher lifecycle costs in buildings—for both fan-coils and AC. Someone must come, replace filters, sometimes with work-at-height permits, outside business hours, etc. If you calculate LCC—life-cycle cost—BKT/TABS should be in the same table as other systems. TABS are permanently embedded with minimal maintenance—mainly water quality checks.

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Someone might drill into a pipe, but it can be located and repaired with couplers—so the system remains viable. Some argue TABS aren't ecological because concrete with embedded plastics complicates recycling in 50–100 years. However, today's technologies for concrete recycling are advanced: magnets remove rebar, air jets separate plastics, leaving clean aggregate. Modern recycling plants deliver separated streams—steel, plastics, and clean concrete aggregate. These are the core principles of TABS from the physical and technical viewpoints. Regarding storage, we looked at an interesting study: how to store energy in these systems. The absolute numbers depend on energy prices, but the ratios are consistent.

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With TABS we can "store" about 40 kWh per 100 euros (illustrative) in the structure. Storing heat in water via heat pumps yields only around 13 kWh per 100 euros—tanks are expensive and take valuable technical-room space that costs thousands of euros per square meter. Battery storage is currently very expensive with technical limits for cooling, operation, and life—often quoted around ten years. If we channel solar into TABS, the building structure becomes the most economical "battery" for long-term

building energy and climate adaptation. Applications—how do we apply these systems?

APPLICATIONS

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First, for any ceiling radiant heating/cooling, integrated planning is essential.

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Without it, frankly, it won't work—that's a fundamental shift in how we design. Ceiling radiant can be done as gypsum panels, plastered-in systems, and—our core—embedded in concrete, either above or below the bottom reinforcement. Today prefabricated panels are also very modern—filigree panels into which pipes can be integrated. The choice depends on spans and coordination with other trades. We try to tailor systems to users and architects; there's never only one solution. We aim for the solution that suits architect, developer, and occupant.

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Question: you mentioned placing pipes either below or above the bottom reinforcement. How do you decide?

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By performance and flexibility for future layout changes. Below the bottom rebar gives faster response, less storage, and different cost. The more prefabrication you use, the somewhat higher the upfront price—but construction is faster.

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In Austria and westward, prefabrication is economically attractive; to the east, labor costs are lower and installers often tie pipes directly to the top of the bottom rebar on site. It's largely an installation-cost question. In single-family homes you can mix approaches; in large complexes—300–400 apartments—the unit install cost becomes decisive.

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Is it cheaper as a prefabricated solution...?

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Currently prefabrication tends to cost more upfront, but the build goes faster. Estimators must include secondary effects: site overheads and construction loan interest. If you shorten the schedule by four months, financing and overheads drop. So equipment price alone doesn't decide the system's total cost. With TABS, once the shell is up and the roof and façade/windows are on, we can start heating immediately.

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As for installation speed—placing pipes below the reinforcement tends to be quicker than above, yes?

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Likely yes, though coordination matters. Looking ahead, we will move toward prefabrication. Our partners in Vienna already deliver over a thousand apartments per year via prefabrication—much like panelized housing used to be built. We're returning to prefabricated bathrooms, risers, slabs—where TABS, electrical, and plumbing are integrated in the factory. The architect draws the layout, the finished panel arrives on site to its exact position, and we assemble like a kit.

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This is the future for TABS—and building generally. Regarding pipe spacing: denser isn't always better. Even though I represent pipe manufacturers, I'm arguing against myself—we always aim to offer the right solution for the client. Going from 20 cm to 10 cm doubles pipe length (and cost) for maybe ~13% more peak output. We need the right balance for today's low-energy buildings. Typical spacing in concrete is 15–20 cm. Going tighter adds cost with marginal benefit, and over time the performance equalizes because what matters is phase shift—when the structure is charged.

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Key rules: routing, insulation of supply lines, and manifold locations. Put manifolds in rooms where they don't bother anyone. Avoid high-risk drill zones: in front of large glazing, balcony doors—remember, the first owner may know where the pipes are, but the next owner in ten years may not. Leave safe zones around light fixtures, kitchen islands, etc.

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Common sense and integrated planning prevent future problems. We're intervening in a building for 50–100 years, so we must assume layouts won't shift across balcony doors and windows. Controls: use weather-compensated heating; for cooling, consider humidity. A Slovak firm is already testing AI-based predictive control using weather forecasts. Dew-point sensors are used case-by-case—we prefer room-mounted sensors rather than embedding electronics in the structure: anything embedded will eventually fail, and it should be easily replaceable.

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Keep systems simple so nothing breaks, and if it does, components are easy to swap. Structural requirements: slab thickness usually doesn't change for TABS—so we're not increasing the investor's costs. Other materials—walls, ceilings—generally don't constrain TABS except at structural transitions that require coordination. Plasters should not be thermal-insulating; with high-quality flat concrete, thin skim coats are common—traditional thick plasters to level masonry irregularities are less needed.

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New build vs. retrofit: TABS are suitable for new construction; embedding them in retrofits is complicated. In renovations use plastered-in wall/ceiling radiant systems, still low-temperature. The illustrations show above- and below-rebar placements. The difference in W/m^2 is small and often unnecessary. Typical office peak cooling demands are about $60\text{--}65 \text{ W/m}^2$; apartments are significantly lower, so above-rebar is usually enough. For faster response, prefabricated filigree panels with OBKT-type channels or below-rebar placement can be used—local output is higher, but over time it evens out. Pipe layouts can be spiral (“snail”) or double meander, connected directly or via Tichelmann loops—details for technologists. We need clear locations where the ceiling loops exit to manifolds. Many practical examples exist—from the Nádvorie courtyard projects on Štefánikova/Pekárska in Trnava...

ADAPTATION TO CLIMATE CHANGE

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where TABS have been in place for over twelve years (around 2014), to larger sites like Alej in Trnava, or Hausberg—which won the 2025 CÉZAR public award this year (architect Ilja Koček). Climate adaptation: combine TABS with dry ground heat exchangers and local energy solutions. In Positive Energy Districts (PED), or brownfields transformed into PEDs, these solutions fit naturally. Temperature lifts are very small: supply water to ceilings is very low—up to $\sim 30 \text{ }^\circ\text{C}$ for heating. If you put your hand on a radiator at $30 \text{ }^\circ\text{C}$, you might think it isn’t heating—yet through the ceiling it’s very pleasant.

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At my home with 3.8 m ceiling height I heat with $28 \text{ }^\circ\text{C}$ water at $-11 \text{ }^\circ\text{C}$ outdoors. Once the mass is charged, you rarely need to switch the system off; it’s very comfortable. TABS are often paired with dry ground heat exchangers or shallow geothermal. The indoor environment is healthy—uniform heat and coolth distribution with no drafts and low health risk. Avoid thermal shock: the indoor–outdoor temperature difference in summer should not exceed $\sim 6 \text{ }^\circ\text{C}$. At $26 \text{ }^\circ\text{C}$ with ceiling cooling many clients say they never want another system—despite thermostats showing $22 \text{ }^\circ\text{C}$ elsewhere.

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It’s a very comfortable environment. Of course there are limits; it’s not a perpetual-motion machine—you must adapt expectations to climate realities. If there are three hot weeks, do you truly need $22 \text{ }^\circ\text{C}$? Those who haven’t lived with BKT/TABS may not realize that $26 \text{ }^\circ\text{C}$ with radiant cooling feels better than $22 \text{ }^\circ\text{C}$ with many other systems. Personally, $24\text{--}25 \text{ }^\circ\text{C}$ is perfectly fine—and sometimes even feels cool. This is a major contribution to building climate resilience: very low water temperatures in TABS, and minimal maintenance. We have fewer technicians available for HVAC service; the systems must be designed to be sustainable with minimal maintenance needs.

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Controls should be simple. My strong recommendation from experience: do not show room temperatures on the local controller; let it control quietly in the background—perhaps AI-assisted. In such buildings you should simply feel comfortable. Our thermostat design hid readings; you press it only when you feel discomfort and want a change—and with TABS that change takes hours, not minutes. The essence of TABS is continuous operation: if cooling starts in May, it often runs through September or October as needed.

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You mentioned limits—the long response time to changed conditions or setpoints. Unlike air systems that can change temperature quickly, here the strength (storage) is also the weakness (slower response). The real question is: how often do you truly need a different temperature within a couple of hours if the baseline is already comfortable?

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People like to “tweak,” but education helps. I’m in my forties and have lived through four heating paradigms: my grandmother’s wood-fired stoves, then coal at my parents’, then gas with radiators, and now at home I have a tempered concrete core—TABS—with ground-water heat pumps. That’s in just forty years, whereas for 300–500 years before it was wood. We’ve become used to instant comfort, but for sustainability some upfront investment is needed for long-term comfort. Fossil fuels shouldn’t be a societal lever to keep raising bills; local systems put control back with the user.

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This system is local—my own source—and sustainable thanks to storage. With PV I can charge via the heat pump and use it all day. A modern house, with enough PV, may only need six to eight hours of heating per day, then coast on stored energy. That may sound at odds with “continuous operation,” but to be energy-efficient I prefer not to export power to the grid—better to produce heat “excessively” at low-cost times and store it in concrete.

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As shown in that graph: electricity from PV is “noble”—you can do many things with it. But the portion you don’t need as electricity is simpler, cheaper, and greener to store in its native form—heat or coolth. The investment per kWh stored in water or concrete is far lower than in batteries.

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Exactly—and that includes the ecological footprint of making batteries vs. other storage media.

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You must view all this as a whole—PV source, distribution, emitters, controls. It's not enough to just drill geothermal bores and think you're done. The design must be holistic from A to Z.

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Integrated.

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Yes—and TABS are the optimal partner. If you drill bores and then use fan-coils, it will work, but long-term efficiency won't be as high as it could be. Thank you—and thanks to Miro—for this pleasant discussion about sustainable energy solutions.

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Thank you for coming.