Abstract Traditional chimney structures were simple yet complete. Natural inflow and outflow occurred simultaneously, allowing air to move on its own. However, in modern high-rise apartments, this natural order has been abandoned in favor of a system based solely on forced exhaust using fans. The problem lies in the fact that this shift was made without considering the structural fundamentals. The fan must push air out without any natural inflow, and the damper, installed to prevent backflow, ends up completely blocking the flow, ultimately shutting down the system.

Nevertheless, people often misunderstand this as a problem with the hood's performance, failing to recognize the structural flaws in the chimney itself. This study aims to correct this misconception and proposes a nature-centered design that induces airflow by opening the lower intake of the chimney. This is not merely a replacement of components but a return to a "forgotten structural truth," demonstrating that problems can be solved through fundamental design rather than complex machinery.

📘 1. Introduction 1.1 Background of the Study Chimneys are one of humanity's oldest ventilation systems. Traditional chimneys—such as fireplaces, furnaces, and smoke outlets—have always adhered to one principle: flow only occurs when inflow and outflow happen simultaneously.

When air is heated, it rises, and cold air fills the void from below. This simple mechanism worked flawlessly for centuries. There were no fans or dampers, yet the airflow remained alive.

However, the chimneys in modern high-rise apartments have forgotten this principle. Designers eliminated natural inflow and attempted to handle all exhaust purely through mechanical fans. The results:

- Stagnation of airflow on upper floors
- Backflow when lower-level hoods are opened
- Complete disruption of flow due to dampers
- Fan overload and noise issues
- Misconception that performance depends solely on hood strength

This system deteriorates over time. People misinterpret the root of the problem as insufficient hood power and try to solve it with stronger fans and more complex ductwork. However, the fundamental issue lies in the structure itself.

1.2 Research Necessity and Purpose This study is based on the following awareness:

- The core problem lies not in the hood or fan, but in the structural design itself.
- Dampers, intended to prevent backflow, actually intensify flow disruption.
- The current chimney structure contradicts basic principles of fluid dynamics.

To address this, we propose:

- Opening lower inlets to structurally re-establish “inflow → outflow” order
- Positioning the fan as a supporting device rather than the core driver
- Forming an “air highway” throughout the chimney line to eliminate stagnation

This is not just a technical fix, but a restoration of the chimney's original identity—a structural and philosophical recovery.

🟦 2. Fluid Dynamic Issues in Conventional Chimney Structures 2.1 Straw Effect and Air Stagnation Modern apartment chimneys rely entirely on forced exhaust via fans. With lower inflow blocked, the system demands that air be pushed vertically over 60 meters—a scenario akin to sucking water from a straw that's sealed at the bottom.

The air stagnates, and dampers worsen the problem by completely obstructing the flow. Though meant to prevent backflow, they create vacuum-like isolation within the duct, pushing the fan into overload.

2.2 Diffusion Problem and Backflow Air moving from narrow to wider ducts depends not on pressure but on diffusion. In current systems, narrow pipes from each unit merge into a main duct. Instead of compressing and speeding up airflow, this causes diffusion → stagnation.

When a lower-floor hood is opened, it causes backflow in upper floors due to the reverse pressure gradient. Even with strong fans, if the duct system is congested, the force boomerangs back as resistance.

2.3 Need for Historical Reversion in Chimney Design Traditional chimneys always considered lower inflow. Fireplaces, furnaces, and flues functioned on the principle of inflow → outflow, and air circulated naturally without fans.

Modern chimneys, however, entrust everything to mechanical fans, disrupting structural circulation. Rather than more technology, what's needed is a return to structure-led flow design, based on time-tested principles.

📘 3. Globalization of Hood-Centric Thinking and Structural Blind Spots 3.1 Global Repetition of Design Errors Modern apartment chimney structures have been replicated almost identically across countries and regions. This is because hood-centric thinking has spread among architects worldwide, establishing forced exhaust without lower inflow as the standard.

Architectural manuals and design drawings focus solely on top-side exhaust, making the damper a “standard component.” As a result, most newly constructed apartments repeat the same structural mistake, attempting to solve the problem through fan performance improvements alone.

3.2 Shifting Structural Responsibility When exhaust failure or backflow occurs, the issue is simplistically attributed to hoods or fans. Yet no matter how powerful the hood is, it cannot overcome stagnation within a flawed chimney system. The real problem lies in the structure, but responsibility is always redirected toward the device.

Consequently, construction firms opt for stronger fans and wider ducts while ignoring fundamental structural improvements. This vicious cycle conceals the inherent fluid inefficiency of the chimney system, causing users increasing discomfort over time.

📘 4. Proposal for Structural Improvement 4.1 Necessity of Lower Inlet Opening To escape from closed exhaust structures, natural inlets must be opened at the bottom of the chimney. Once inflow occurs, outflow naturally follows. Structurally, this creates a positive cycle that reduces reliance on mechanical fans and provides a solid foundation for natural exhaust.

4.2 Design of an Air Highway Structure In the current system, stagnant air cannot enter from below. Each unit’s exhaust functions like a “bottleneck,” disturbing overall airflow. If the lower structure

is opened, natural inflow becomes possible, and the interior chimney space can act as an “air highway.”

The principle of this highway is expressed in the following equation:

$$Q = A \cdot v \quad \Rightarrow \quad v = \frac{Q}{A}$$

Where:

- Q: Airflow rate
- A: Cross-sectional area of the duct
- v: Air velocity

If a sufficient area A is ensured, air velocity v remains stable even as flow rate Q increases, maintaining consistent flow throughout the system.

4.3 Replacement of the Damper Dampers are installed to prevent backflow but often paralyze the system by cutting off airflow. Instead, it is preferable to introduce smart valves or variable backflow-prevention systems with automatic open-close functionality.

These structural improvements are illustrated in the diagram below.

📘 5. Conclusion This study revealed that stagnation, backflow, and exhaust failure in modern apartment chimneys stem from structural flaws rather than device limitations. Expecting fans alone to handle vertical exhaust over several floors contradicts fluid

dynamics. Dampers exacerbate the problem by blocking the flow entirely.

The solution is simple yet fundamental:

- Open the lower chimney → restore inflow–outflow balance
- Use fans as supplementary tools → reduce overload and noise
- Build an air highway within the chimney → eliminate stagnation

This is more than a technical change; it is a philosophical shift. It reminds us that the answer lies not in technology, but in structure. The natural ventilation principles of traditional chimneys still hold value today, and by restoring them, we can create healthier and more sustainable indoor environments.

🖼️ The diagram below visualizes the key ideas proposed in this study, including the opened lower inlet, air highway formation, and alternatives to the damper:

(*This diagram highlights the restored airflow order compared to existing structures by showing natural inflow through the lower inlet and smooth exhaust through the upper outlet.*)