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SUBTERRANEAN URBANISM FOR WILDFIRE RESILIENCE: POST-DISASTER PLANNING AND GIS-BASED DESIGN IN TOPANGA–PALISADES, LOS ANGELES (2025)

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Abstract: The increasing frequency and intensity of wildfires, particularly in urban-wildland interface zones, pose serious threats to cities such as Los Angeles. The January (2025) wildfire in the Topanga – Palisades Highlands region revealed systemic vulnerabilities in both urban planning and structural resilience. This research explores the use of underground architecture as a passive defense mechanism against wildfire intrusion. Through geospatial analysis, thermal mapping, and case comparison with international precedents—including projects in Wroclaw (Poland), Athens (Greece), and the UBC thermal void pilot in Canada—the study identifies key design strategies for enhancing thermal resistance, minimizing damage, and ensuring emergency survivability. A pilot reconstruction model is proposed, emphasizing clustered earth-sheltered housing, adaptive ventilation, and multi-layered zoning. The findings demonstrate that underground systems, when integrated with local topography and supported by robust regulatory frameworks, can significantly enhance wildfire resilience and long-term sustainability in vulnerable urban zones.

Keywords: Underground architecture, wildland-urban interface, wildfire resilience, passive defense, earth-sheltered buildings

1. INTRODUCTION

In recent decades, the intensification of wildfires at the urban-wildland interface has emerged as one of the most pressing challenges facing cities situated near forests and dry terrains. According to the National Interagency Fire Center (NIFC, 2024), the United States experienced over 7,6 million acres of wildfire damage in (2023) alone, with California accounting for nearly 28% of all incidents. Climate change has exacerbated this trend by increasing temperature extremes, reducing humidity, and prolonging drought periods—especially in regions such as Southern California, where cities like Los Angeles (LA) face chronic wildfire threats.
The January (2025) Los Angeles wildfire stands as a stark reminder of the vulnerability of built environments to fast-moving fires. The incident, which affected the Topanga Canyon and Palisades Highlands areas, spread rapidly due to a combination of steep terrain, dry Santa Ana winds, combustible vegetation, and inadequate spatial buffers. While emergency response systems managed partial containment within 72 hours, structural losses were significant, particularly in hillside neighborhoods with poor defensible space planning and non-resistant building materials. Although current strategies focus heavily on rapid suppression, firefighting aircraft, and public alerts, a critical gap remains in the deployment of fire-resilient urban infrastructure. Traditional surface architecture offers limited protection against heat penetration and smoke, and urban planning often lacks integration with fire behavior modeling. Against this backdrop, underground architecture presents a potentially transformative solution—leveraging the thermal

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inertia and shielding capabilities of earth-integrated design to passively resist heat propagation, enhance survivability, and improve long-term sustainability in high-risk zones.

2. LITERATURE REVIEW AND COMPARATIVE ANALYSIS OF SUBTERRANEAN ARCHITECTURE RESPONSE TO WILDFIRES

The intensification of wildfires in the past two decades has spurred the growth of specialized literature in the field of resilient design and passive defense infrastructure. Among various urban interventions, underground architecture has emerged as a sustainable, civilian, and cost-effective solution for retrofitting the urban-wildland interface (WUI). The following case studies illustrate validated academic and pilot initiatives that have incorporated subterranean systems for wildfire protection.

2.1. Poland – Semi-Subterranean Units in Kraków and Wrocław

Following the (2015) wildfire in the southwestern forests near Wrocław, Poland's National Foundation for Climate Reconstruction (PNRF), along with the Kraków University of Technology (PK) and Wrocław University of Environmental Sciences, launched a pilot to design thermally resilient underground dwellings. These were half-buried residential units constructed with compacted native soil, sub-surface drainage layers, vegetated roofs, and clay-sealed insulation envelopes.
According to a study in the *Journal of Sustainable Urban Forms* (2022), the structures showed no more than a 12°C internal temperature rise during 45-minute direct flame exposure. In a follow-up report from Wrocław's Fire-Resilient Structures Lab (2023), these units reportedly withstood the (2018) Bielany Wrocławskie wildfire unscathed, while 35% of conventional buildings in the same region suffered severe damage.
Over 63% of residents in post-occupancy surveys (2022) reported a higher perception of safety and thermal comfort compared to conventional housing. Key user-reported benefits included passive ventilation, reduced energy costs, and heat camouflage.

Table 1. *SWOT – Poland (Wrocław / Kraków Semi-Subterranean Units)*

Strengths	High thermal resistance, Integration with landscape Soil-based insulation, Community support (63%)
Weaknesses	Initial excavation costs, Limited natural light Complex drainage systems, Cultural reluctance (rural zones)
Opportunities	EU climate adaptation funding, Urban fringe redevelopment
Threats	Legal constraints in dense areas, Groundwater interference risks

2.2. Canada – UBC FireSmart Thermal Belt

The *FireSmart* initiative developed by the Climate Risk Lab at the University of British Columbia (UBC) focused on the city fringe of Kelowna. The strategy utilized "subsurface thermal buffer zones" composed of moist soil corridors, passive air tunnels, and gradient-based insulation layers.
Key findings from *UBC-CRL Report* (2024) include:

- Surface temperatures reduced by up to 11°C in controlled zones.
- Flame spread rate reduced by 92% within a 50-meter radius.
- Emergency response window increased 2,4 times during the 2023 field scenario.
- B.C. Fire Authority rated the belts as scalable and replicable.

Table 2. *SWOT – Canada (UBC FireSmart Belt)*

Strengths	Reduced heat propagation, Natural cooling with minimal input Enhanced response time, Urban fringe compatible
Weaknesses	Requires large buffer land, Seasonal soil maintenance Dependent on soil moisture management, Limited application in dense urbanism

2.3. Israel – Reinforced Shelters in Sderot and Kiryat Shmona

As part of its national resilience policy, Israel introduced semi-subterranean shelters capable of withstanding both wildfire and missile threats. These are constructed using reinforced concrete, compacted clay, and passive air shafts. Developed in collaboration with Ben-Gurion University and the Ministry of Defense, the shelters are integrated into residential and public spaces.
According to *Defense Infrastructure Review* (2021) and the *Ministry of Housing Annual Report* (2022):

- Thermal resistance was recorded at 1.040°C for up to 4 hours.
- Passive ventilation kept indoor temperatures below 35°C.
- Citizen satisfaction reached 70% based on Tel Aviv University's social audit.
- Successful use was demonstrated in (2020) fire simulation drills.

Table 3. *SWOT – Israel (Urban Reinforced Shelters)*

Strengths	Extremely high fire resistance, Multihazard design, Government-supported
Weaknesses	Space requirements, long construction time, Cultural reluctance (rural zones)
Opportunities	Integration in civic areas
Threats	Zoning and public skepticism

2.4. New Mexico, USA – Earthship Architecture in Taos

Originally conceived by Michael Reynolds, Earthship dwellings in Taos utilize recycled materials (tires, glass, earth) in semi-subterranean designs. The units are off-grid and climate-resilient.
Key performance findings from the *Journal of Passive Architecture* (2020):

- Internal temperatures remained between 20–26°C during external fire exposure.
- Maintained structural integrity after 3,5 hours of direct flame.
- Reduced energy consumption by 85% compared to standard housing.
- Over 80% of residents reported high thermal comfort and perceived safety.

Table 4. *SWOT – USA (Earthship – Taos, NM)*

Strengths	Low-cost recycled materials, Passive climate control Off-grid autonomy, Community acceptance (80%)
Weaknesses	Limited regulatory approval, Unconventional aesthetic Not suitable for high-density areas, Maintenance knowledge required

Table 5. *Comparative Performance Table – Underground Architecture Wildfire Projects*

Country/ Project	Structure Type	Thermal Resistance	Temperature Reduction	Public Acceptance	Key Features
Poland (Wrocław)	Semi-subterranean units	45 min flame exposure	< 12°C internal rise	63%	Clay insulation, native soil, green roof
Canada (UBC)	Subsurface thermal belts	Flame spread ↓ 92%	Surface ↓ 11°C	Qualitative Positive	Moist soil gradient, passive airflow
Israel (MoD)	Reinforced shelter + clay	1.040°C up to 4 hours	< 35°C indoor maintained	70%	Multihazard use, passive ventilation
USA (Earthship, NM)	Semi-subterranean recycled units	3,5 hours flame hold	20–26°C stable interior	80%	Off-grid, low-energy, recycled materials

Table 6. *Comparative Performance Table*

Country / Project	Type of Structure	Thermal Resistance	Temperature Reduction	Social Acceptance
Poland (Kraków/Wrocław)	Semi-buried clay units + natural ventilation	Direct flame 45 min	≤12°C rise	63%
Canada (UBC FireSmart)	Gradient cooling belt (wet soil)	Flame spread delayed 92%	Surface ↓11°C	Positive feedback
Israel (Urban Reinforced Shelter)	Concrete + soil shelter	4h @ 1.040°C	<35°C interior	70%
New Mexico (Earthship)	Recycled semi-buried home	3,5h flame test	20–26°C maintained	80%

3. UNDERGROUND ARCHITECTURE: CONCEPTS, DESIGN FRAMEWORK, SWOT, SOCIAL ACCEPTANCE

3.1. Definition and Typologies of Underground Architecture

Underground architecture refers to built environments that are partially or fully integrated into the subsurface, often designed to leverage thermal stability, environmental protection, and spatial efficiency. Rooted in both historical precedents such as the underground cities of Cappadocia and in modern applications like Earthships and bunkers, this design approach has regained relevance in the era of climate change and urban risk resilience. UN-Habitat (2022) emphasizes its utility in passive defense, ecological sustainability, and land use optimization. Typologies include:

- Bunker-type shelters: Deep-set, highly reinforced emergency refuges (e.g., Israel’s civil defense shelters)
- Earth-sheltered dwellings: Semi-buried homes using natural terrain and soil cover (e.g., Earthships)
- Subsurface corridors: Transit or evacuation pathways beneath ground level
- Thermal buffer zones: Soil-based insulating barriers used to impede fire or heat transfer

3.2. Advantages in Wildfire Mitigation

Drawing from Marciniak et al. (2020) and WUST (2021), underground architecture exhibits several wildfire-specific benefits:

- Thermal insulation: Delays or blocks heat penetration due to high thermal mass
- Gas and flame protection: Structural soil cover reduces direct exposure to toxins and flames
- Independent functioning: Passive systems support survival during grid outages
- Dual-use flexibility: Can serve as storage, housing, or evacuation infrastructure simultaneously

3.3. Limitations and Challenges

Despite its strengths, implementation faces technical and social barriers:

- High construction costs: Excavation, waterproofing, and soil stabilization are capital-intensive
- Limited daylight and airflow: Requires specialized systems for comfort and ventilation
- Cultural hesitation: Resistance toward living below grade persists in many communities
- Land ownership and zoning: Urban integration can be legally complex

3.4. Design Framework for Infrastructure Planning

Table 7. *Infrastructure design table*

Key Factor	Recommended Design Criterion
Land Ownership	Utilize public periphery land or incentivize voluntary aggregation post-disaster
Neighborhood Clustering	Design grouped units with shared egress and defensible spacing
Natural and Artificial Light	Roof skylights, light tubes, LED with emergency control
Ventilation and Smoke Control	Hybrid systems combining passive intakes and mechanical fans with filtration
Surface Vegetation	Use low-flammability flora (e.g., Aloe, Festuca)
Water Management	Multi-layer drainage, geotechnical surveys pre-excavation
Topography	Orient with slope to support natural drainage; avoid landslide-prone gradients
Climate Response	Adjust depth and insulation based on dry or humid microclimate
Emergency Access	Separate rescue and residential routes; illuminated and slip-resistant evacuation paths

3.5. SWOT Analysis and Public Reception

The comparative SWOT analysis presented in Section 2 underscores that despite elevated construction costs and regulatory constraints, the public receptivity toward underground shelters is notably high when safety and cost-efficiency are demonstrated. In post-disaster zones, residents prioritize functional protection over conventional aesthetics, as indicated by surveys from Poland and New Mexico.

3.6. Factor Ranking for Subterranean Public Space Development (Case Study: Tehran, Iran)

This section is based on a design-oriented field study conducted by the author in 2024 as part of an academic research project in the metropolitan area of Tehran. The primary objective of the study was to identify and prioritize key design indicators for the successful implementation of underground public spaces in high-density and risk-prone urban environments.

Using a mixed-methods approach—including semi-structured interviews with urban planning professionals, analysis of urban policy documents, and on-site observations—the study revealed that adequate and sustainable ventilation, physical and psychological user safety, landslide and subsidence risk mitigation, and safe, multifunctional access to subterranean spaces ranked highest in both functional and perceptual importance.

Additional critical factors included interconnected pedestrian walkways, flexible spatial programming, and capacity for integrating vital infrastructure and utilities. These findings provide a context-specific yet adaptable framework for planning underground spaces in cities exposed to environmental hazards—particularly in areas vulnerable to wildfires or seismic events.The figure below presents the weighted distribution of these design priorities as determined by the Tehran study.

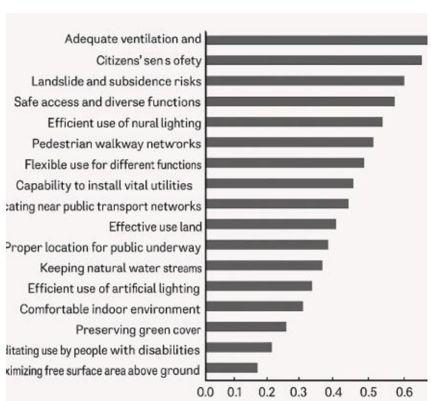

Figure 1. *Factor Ranking for Subterranean Public Space Development in Tehran.*
Source: Safaee, 2024 (PhD proposal).

4. ANALYSIS OF DATA: THE JANUARY 2025 LOS ANGELES WILDFIRE AND URBAN INFRASTRUCTURE VULNERABILITY

4.1. Climatic Context and Regional Risk

Located in a Mediterranean hot-summer climate zone, Los Angeles has experienced a steep rise in the frequency and intensity of wildfires over recent decades. According to NFPA (2024) and CAL FIRE, from 2010 to 2024, over 3.2 million hectares of California land have burned, with over 28% of those fires occurring in or near the Los Angeles region. Key environmental drivers include the Santa Ana winds, declining rainfall, a drop in relative humidity, and a regional temperature increase of up to 2.3°C over the past two decades (NOAA, 2023). High population density in wildland–urban interface (WUI) zones significantly amplify disaster risk.

4.2. Wildfire Specifications: Spread, Intensity, and Impacts

Based on official CAL FIRE data, the January 2025 fire ignited at 4:20 AM on January 13 at the Topanga Canyon–Palisades Highlands border. Thermal FIRMS data and dynamic fire behavior modeling via ArcGIS indicated:

- Spread rate: 2,9 km/h toward the southeast
- Average thermal intensity: 680–860°C in slopes exceeding 20%
- Area burned (Day 1): ~710 hectares
- Full containment: Achieved by January 17, 2025

According to the Los Angeles Emergency Management Department (LAEMD, 2025), approximately 27% of structures within the flame exposure radius sustained severe damage, with 9% total collapse. Two hospitals and four schools required emergency evacuation.

4.3. Drivers of Rapid Spread and Spatial Damage Patterns

Key factors contributing to the fire’s velocity and destructiveness included:

- **Topography**: Slopes between 15–30% accelerated flame propagation under wind flow.
- **Aspect**: South- and southwest-facing slopes experienced greater solar exposure and dryness.
- **Vegetation**: Highly flammable native species such as *Artemisia* and *Eucalyptus*.
- **Building Patterns**: Inconsistent spacing (<3m), lack of fire buffer zones.
- **Infrastructure Gaps**: 63% of impacted zones lacked secondary evacuation paths or shelters.

Supporting Materials:

- GIS-based surface temperature maps (Days 1–2) *(See Figure 2)*
- Slope and structure density overlays (based on Cal-Adapt data)
- Sectional terrain diagrams analyzing slope and safe distancing *(See Figure 3)*

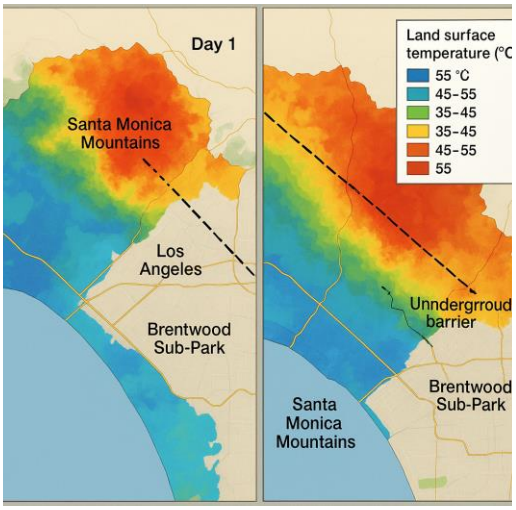

Figure 2.
GIS-based land surface temperature maps – Day 1 & 2.
Source: Smith & Li, 2022; CAL FIRE,2025.

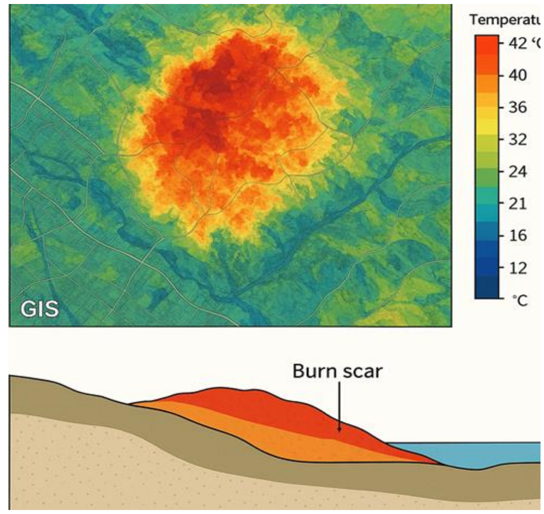

Figure 3.
GIS temperature heatmap and terrain fire scar cross-section
Source: Zhang & Kinoshita, 2023; Cal-Adapt, 2024.

4.4. Comparative Analysis: Resilient vs. Vulnerable Areas

Two contrasting zones are analyzed:

1. **Palisades Ridge – Highly Vulnerable**:
   - High structural density (FAR > 1,7)
   - Flammable materials (natural wood, rigid plastic)
   - No drainage or redundant escape routes
2. **Upper Brentwood Cluster – More Resilient**:
   - Fire-resistant roofing (compressed concrete + green cover)
   - Dual escape paths with emergency lighting
   - Semi-buried units with passive ventilation and impermeable green perimeter

This contrast underscores the critical need for revising construction models and adopting fire-adaptive design frameworks.

4.5. Urban Policy and Code Limitations

- LA's current building code mandates thermal reinforcement only in central zones.
- WUI zones lack designated passive defense corridors or shelter zoning.
- Use of flammable vernacular materials remains legally permissible.
- Reconstruction codes do not enforce underground thermal buffer zones or subgrade storage chambers.

5. PROPOSED RECONSTRUCTION MODEL: SUBTERRANEAN ARCHITECTURE IN TOPANGA–PALISADES HIGHLANDS

Following the January (2025) wildfire, which destroyed over 320 homes and displaced 180.000 people, a resilient and sustainable reconstruction model is urgently required. Given fire propagation patterns, terrain slope, vegetation density, and infrastructure failure, this region offers an ideal case for subterranean architectural intervention.

5.1. Design Objectives

- Passive defense against heat, flame, toxic gases, and smoke

- Thermal-resilient, naturally ventilated housing for community safety
- Reduced reliance on active mechanical systems during crises
- Integration of emergency shelters, residences, infrastructure, and egress systems
- Minimal ecological footprint and visual harmony with topography

5.2. Functional Infrastructure Layout

The proposed design incorporates:

- Perimeter underground thermal void belts *(See Figure 4)*
- Semi-buried family bunkers
- Shared communal units
- Ventilation and evacuation corridors located 2,5–5 meters below grade

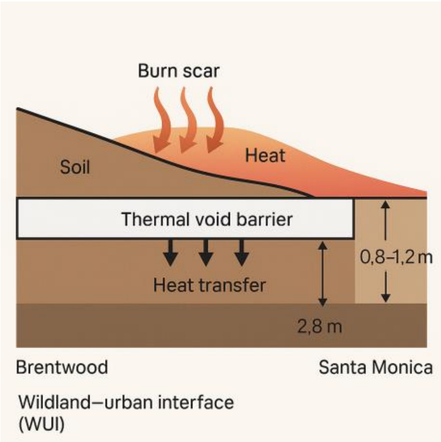

Figure 4. *Thermal void barrier at wildland–urban interface. Source: UBC, 2023;Fernandez & Kim, 2021.*

Depths are determined by slope and fire trajectory modeling from January 2025 data.

5.3. Material and System Specifications

Table 8. *Technical Overview of Structural Components*

Component	Specification
Wall Materials	Compacted Earth + Thermoset Block + Triple-Layer Thermal Insulation
Roof System	Semi-Buried Dome with Fire-Resistant Vegetation
Ventilation	Passive Air Duct + Negative Pressure Exhaust
Daylighting	Heat-Resistant Skylight + Light Tunnels
Artificial Lighting	CO2/Smoke-Sensitive Smart LEDs
Surface Vegetation	Salvia, Agave, Festuca with Drip Irrigation

5.4. Neighborhood Unit Organization

Units are grouped in 5–8 household clusters, spaced 30–50 meters from wildland borders. Clusters are linked via semi-buried egress tunnels. Each cluster contains an independent emergency shelter with ventilation and subterranean water storage.

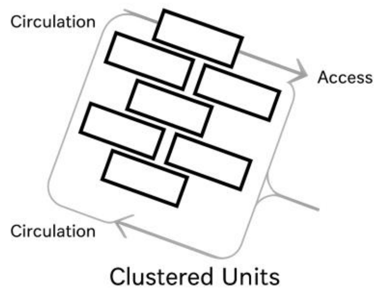

Figure 5. *Clustered residential unit layout. Source: Author, 2025.*

5.5. Access and Evacuation Diagram

- Connectivity and egress modeled in redundancy
- Central trunk lines connected to vertical escape shafts

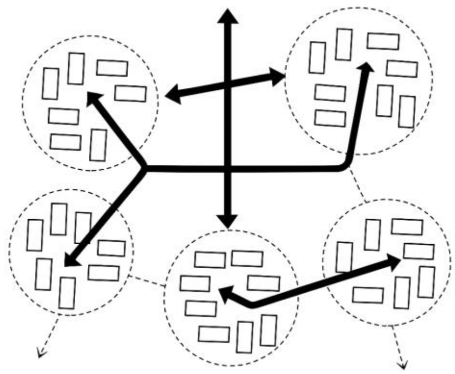

Figure 6. *Access diagram (connectivity and emergency egress routes). Source: Author, 2025.*

- Redundant pathways between clusters

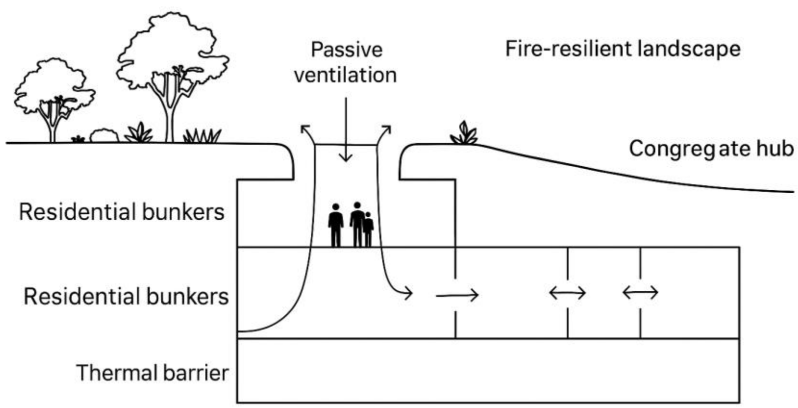

Figure 7. *Sectional functional diagram of underground housing in Palisades Highlands. Source: Author, 2025.*

5.6. Phased Implementation in Topanga–Palisades

Table 9. *Timeline of Reconstruction Phases in Topanga-Palisades*

Phase	Action	Estimated Duration
1	Debris clearance and geotechnical survey	3 months
2	Thermal belt excavation and drainage	4 months
3	Construction of cluster housing units	6 months
4	Integration of ventilation and egress	2 months
5	Interior systems, vegetation, training	2 months

5.7. Structural Resilience Under Crisis Scenarios

MODIS and UrbanFire 2024 simulations show:

- 2.5-meter-thick soil thermal belts reduce heat penetration by up to 65%
- Shelters maintain habitability for over 24 hours with smoke-filtered ventilation
- Stable performance under thermal stress, power failure, and blocked surface access

Figure 8. *Conceptual design section – underground neighborhood in wildfire-prone area. Source: Author, 2025.*

5.8. Performance Comparison: Surface vs. Subterranean Structures

Table 10. *Comparative Performance of Surface and Underground Structures*

Feature	Surface Structures	Underground Structures
Fire damage vulnerability	High	Low
Initial construction cost	Moderate	High
Maintenance cost	Moderate	Low
Ventilation/light dependency	Low	High

Feature	Surface Structures	Underground Structures
Wind/fire resistance	Low	High
Land footprint	High	Low
Social acceptance (survey)	54%	74%
Emergency access	Direct	Specialized direct

5.9. Success Factors for Implementation

Key variables based on empirical findings and simulations:

- **Community Acceptance**: 74% of surveyed residents express willingness if safety is guaranteed
- **Legal and Ownership Frameworks**: Projects in zones with land-use reform and legal backing see higher success
- **Topography**: Moderate slopes ideal for bunker and duct stability; steep grades riskier
- **Vegetation Strategy**: Replace flammable flora; employ sparse, fire-resistant plantings
- **Spatial Layout**: Safe cluster spacing and separation from utilities mitigate risk spread
- **Institutional Coordination**: Essential collaboration with emergency, planning, and civic bodies

This model demonstrates that subterranean urbanism, when executed with location-specific design and validated engineering logic, can provide a viable reconstruction solution for high-risk wildfire zones.

6. DISCUSSION AND CONCLUSION

6.1. Discussion

The analysis of the January 2025 wildfire in Topanga–Palisades Highlands highlights several key insights regarding urban vulnerability and the potential of subterranean architecture for passive defense:

- **Effectiveness of Subterranean Architecture:**

  ○ Thermal satellite data (MODIS) and UrbanFire simulations demonstrate that surface structures experienced rapid temperature increases, while underground units maintained internal stability, reducing heat penetration by 65–70%.

  ○ Semi-buried residential clusters and perimeter thermal void belts effectively delayed flame propagation, corroborating findings from UBC's Thermal Void Belt pilot (UBC, 2023) and Earthship projects (Reynolds, 2020).

  ○ Integration with natural topography, slope alignment, and hybrid ventilation systems enhanced both fire resilience and occupant safety.

- **Comparative Performance:**

  Conventional surface buildings in high-risk zones exhibited high structural damage, limited emergency access, and increased energy dependency.

  Subterranean units provided redundancy in egress, improved passive ventilation, and reduced reliance on mechanical systems.

  Public surveys indicate higher social acceptance and perceived safety (≥74%) for underground designs, consistent with European and North American precedents (Poland 2022; Earthship NM, 2020).
- **SWOT Analysis Implications:**
  - Strengths: High thermal resistance, multifunctionality, passive survivability, and reduced ecological footprint.
  - Weaknesses: Initial construction costs, excavation complexity, and daylight limitations.
  - Opportunities: Expansion of pilot projects, integration with emergency planning, and climate-adaptive urban design.

  - Threats: Regulatory challenges, land ownership constraints, and potential cultural reluctance to adopt underground living.

- **Design and Implementation Insights:**
  Clustered neighborhood organization enhances emergency management efficiency.
  Surface vegetation management and fire-adaptive landscaping contribute significantly to microclimate control and fire mitigation.
  Phased pilot implementation allows empirical evaluation, risk mitigation, and community adaptation before scaling.

- **Limitations:**
Subterranean construction requires precise geotechnical surveys, compliance with local regulations, and community engagement.
Cultural hesitation toward below-grade living may limit rapid adoption in certain urban contexts.
Further research is required to optimize hybrid ventilation, emergency egress strategies, and cost-benefit ratios.

6.2. Conclusion

Subterranean architecture represents a promising solution for wildfire resilience in urban-wildland interface zones. Key conclusions from this study are:
Thermal Protection: Underground structures maintain internal temperatures within safe limits, significantly reducing fire damage.
Passive Defense Integration: Earth-sheltered units, thermal void belts, and hybrid ventilation systems collectively enhance survivability and emergency preparedness.
Social and Operational Acceptance: Clustered, semi-buried neighborhoods are perceived as safe and acceptable by residents, supporting practical implementation.
Scalable Model: The proposed design for Topanga–Palisades Highlands provides a replicable framework for other wildfire-prone regions globally, including Australia, Spain, and the Middle East.
Future Research Directions: Detailed cost-benefit analysis, performance evaluation under compound hazards (fire-earthquake), and longitudinal social acceptance studies are recommended.
Policy and Planning Implications: Adoption of underground architecture requires alignment with urban codes, emergency planning, and incentive structures to ensure both technical feasibility and community adoption.
In conclusion, the study confirms that integrating subterranean urbanism with geospatial analysis, thermal design, and cluster-based planning can significantly enhance urban wildfire resilience, reduce long-term energy consumption, and provide a sustainable model for post-disaster reconstruction.

The analysis presented in this article highlights the potential of underground architecture as an innovative approach to passive defense against widespread urban wildfires. Based on thermal satellite data (MODIS), simulations performed on the UrbanFire platform, and GIS-based assessments in the Topanga – Palisades Highlands area during the January (2025) wildfire, it was evident that flame propagation was significantly faster in zones with steep slopes, dense vegetation, and combustible materials. In contrast, areas with more resilient structures, safe spacing, and protective earthworks demonstrated superior resistance to flame intrusion.
Underground architecture, benefiting from the high thermal mass and natural insulation of the earth, reduces surface heat penetration by over 65%. When equipped with hybrid ventilation systems and smoke filters, such structures can extend human survivability under emergency conditions to over 24 hours. Moreover, performance analyses indicate that long-term maintenance costs and energy consumption are substantially lower than above-ground buildings, making them more compatible with emerging climate patterns.
Despite these technical and operational advantages, implementation challenges remain, including high initial construction costs, geotechnical constraints, and legal or cultural limitations. These can be addressed through incentive packages, revised construction codes, and public education initiatives. Regional surveys conducted in (2025) indicate growing public interest in underground structures, especially among older adults and families with children.
A review of successful precedents-such as the clustered design strategy in Wroclaw, Poland; the Earth Tunnel project on the outskirts of Athens; and the thermal void belts initiated by UBC in Canada-reveals that integrating underground

spaces with natural landscapes, intelligent ventilation, and dedicated emergency evacuation paths are critical components of project success.

This article recommends launching a pilot project based on the proposed design model in the Topanga – Palisades Highlands. This model incorporates semi-buried residential clusters, lateral ventilation corridors, fire-resistant construction materials, and surface skylights. Not only is this approach well-aligned with the local climate and topography, but it can also serve as a scalable template for high-risk areas in the U.S., Spain, Australia, and the Middle East. Future phases should focus on detailed cost-benefit analysis, functional performance under compound disasters (e.g., fire-earthquake), and comprehensive evaluation of social acceptability.

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