

## Reconnecting Urban Landscapes through Highway Lidding and Tunneling: A Comprehensive Study on Methodologies, Benefits, and Safety Considerations

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### ABSTRACT

Lidding over or tunneling existing transportation infrastructure is currently under review in several U.S. cities. The main reasons for this are the use of the created space for urban development, the reduction of noise and exhaust fumes for the residents, and, thus, a significant increase in the quality of life. The main aspects to be considered during the planning process are (1) total investment and operational costs, (2) impact of construction works on current traffic, (3) safety and fire protection, and (4) socio-environmental issues. The paper presents some basic planning principles, and experiences of recent urban highway coverages are shared.

### INTRODUCTION

#### Background on Urban Landscapes and Highways

The modern city is a nexus of connectivity, innovation, and culture. Yet, historically, as highways carved their way through urban areas, communities were severed from each other, and entire neighborhoods were eradicated. In the United States, with the signing of the Federal-Aid Highway Act of 1956, the Country's massive and comprehensive Interstate System forged ahead. Due to the popularity and affordability of private automobile ownership, the interstate system and the automobile era were considered great and necessary cultural progress of the time. The darker side of this history is that these interstate projects were often tied together with another national trend at the time termed "urban renewal." Through federal subsidies, large swaths of urban areas, often complete neighborhoods that were considered blighted or undesirable, were seized and demolished to build new housing and infrastructure, including parts of the Interstate System. On the other hand, urban rail transit systems have been built underground for more than a century.

Urban environments, defined by a web of infrastructure, buildings, and bustling activity, grapple with the challenge of harmonizing rapid development and the expectation of streamlined regional mobility with localized quality-of-life concerns, such as multi-modal mobility, access to open space, and public health. The expansive web of highways, once deemed essential for social and economic progress, has historically divided cities, fragmented or even eradicated communities, and altered historic, cultural, and natural landscapes. Urban highways often stand as barriers not only in the physical sense but socially and environmentally as well.

The revitalization and reconnection of urban landscapes has local socio-economic benefits, fosters community cohesion, facilitates accessibility, improves public health, and provides more equitable access to opportunity.

#### The Issue with Highway Noise

Exposure to noise from open roads is a serious issue worldwide. Highway noise is not just a nuisance but imposes a largely unrecognized health threat that is leading to stress, impairing the quality of sleep and increasing the risk of hypertension, stroke and heart attacks (see ). It has an indirect economic impact by health-related downtimes and reduced productivity.

According to a preliminary analysis based on models of road, rail and aircraft noise in 2020 from the Department of Transportation, nearly a third of the U.S. population lives in areas exposed to noise levels of above 45 dB which are associated with adverse health effects (see W1, 2023).

Economists who analyzed health care spending and productivity loss because of heart disease and hypertension have argued that a 5 dB reduction in noise could result in an annual benefit of \$3.9 billion in the US (see Swinburn, 2015).

Studies also show that noise interferes with learning. In the Bronx, NY a classroom facing an elevated railroad showed noise levels of 89 decibels, and lower achievement on standardized tests than the opposite classroom. According to the Journal of Environmental Psychology, once noise abatement measures were implemented, reducing noise by 8 dB, the achievement levels, for the first time, were the same as those of the children on the quiet side of the building (see Bronzaft, 1975).

Thus, tunneling or covering urban highways, leads to a direct reduction of healthcare costs, higher productivity, improved learning environments and a better quality of life, which is invaluable.

### International Approach

In many countries, urban planners strive to bring road and rail traffic underground. New urban highways are built preferably as tunnels, and many existing urban highways have been covered. In Switzerland, a country with 0.4% of the US area, a dozen highway lids have been built in the past two decades. All were constructed under ongoing traffic. Hence, there is plenty of experience regarding highway lids' concept, design, construction, safety, and operation.



**Figure 1** Highway lid, built under traffic (Zurich North Bypass, Switzerland)

### US Approach

As US highway infrastructure ages past its useful life, necessitating major rehabilitation or reconstruction, cities are rethinking the need and form of urban highways. As required by the US National Environmental Policy Act (NEPA) and various state environmental laws, feasibility and scoping studies are first conducted. One example is the recent NYSDOT Kensington Expressway study released in 2023, which considers alternatives, including rehabilitating the existing roadway in-kind, transforming the expressway into boulevards, tunneling, and lidding (see W2, 2023).

Lidding and tunneling promise to mask the disruptive presence of highways and integrate them seamlessly into the urban milieu. By covering sections of highways, we open up opportunities for urban development atop them. These lids and landscapes atop of tunnels, transform the highway's 'negative' space into platforms for multi-modal transportation connections, recreation, commerce, greenery, and community activities. The evolution of this idea is not merely an architectural or engineering marvel; it reflects the evolving needs of urban societies, prioritizing human-centric design, environmental consciousness, and holistic urban planning. When considering existing highways, the existing physical conditions and length of coverage needed can dictate whether a tunnel or lid may be most feasible or cost-effective. In many US cases we will see lidding occurring more frequently than tunneling.

While local and grassroots visioning for removal, tunneling or covering highways began more than half a century ago, feasibility studies and implementation were less common. A turning point from grassroots visioning to State and Federal feasibility studies was the priority the Biden Administration placed on social justice and equity. The Administration's Justice40 initiative set a goal to deliver at least 40 percent of the overall benefits of relevant federal investments to underserved communities. As a result of this policy, the Reconnecting Communities and Neighborhoods (RCN) Program was established to provide grant funding to "redress the legacy of harm from transportation infrastructure" and reconnect communities "by removing, retrofitting, or mitigating highways or other transportation facilities that create barriers to community connectivity, including to mobility, access, or economic development" (see USDOT, 2023). Administered through the US Department of Transportation (USDOT), the RCN Program funding opportunity is approximately \$3 billion. The funding specifically prioritizes disadvantaged communities, with the intent to provide access to daily needs such as jobs, education, healthcare, food, and recreation, while fostering equitable development and restoration.

## THE CONCEPT OF URBAN HIGHWAY LIDDING AND TUNNELING

### Definition and Basic Principles

Highway lidding, often characterized by terms such as "deck parks" or "cap parks," embodies the innovative union of engineering, urban design, and environmental principles. By constructing a platform or "lid" over sections of highways, especially in bustling urban environments, it offers a compelling solution to the challenges of modern urban landscapes. Depending upon the length of the cap, decked over highways may be considered tunnels, due to the need to address exhaust and other fire and life safety issues. Bored tunneling is a more traditionally understood solution amongst engineers and the public, but lidding has and will occur with more frequency in the coming years. The driving force behind both lidding and tunneling is to address the often divisive impact of highways and reintegrate disjointed urban spaces, striving for cohesion and unity. These "lids" are meticulously engineered to bear a diverse range of loads. Whether they are envisioned to be lush green parks, dynamic recreational zones, or foundational supports for buildings and vital public infrastructure, the underlying goal remains the same: to weave the urban fabric back together, and reclaim space for the community.

### Historical Context and Past Implementations

The concept of removing highways from urban surfaces is rooted in history, tracing back several decades when city planners began experimenting with innovative solutions to the challenges of sprawling urban road networks. One of the pioneering examples of this approach in the US can be seen in the transformation of Boston's Big Dig (Central Artery/Tunnel), completed in 2007, where what was once an elevated highway gave way to a tunnel crowned with a verdant greenway (see W3, 2023). As time progressed, the motivations and objectives underpinning highway lidding projects evolved. While initial undertakings might have been predominantly driven by the urge to curb noise and pollution, contemporary endeavors place an equal emphasis on fostering community development, enhancing aesthetic appeal, and catalyzing urban renewal.

## BENEFITS OF URBAN HIGHWAY LIDDING AND TUNNELING

### Urban Development Opportunities

The integration of highway lidding and tunnels into urban landscapes not only bridges physical divides but also presents unparalleled opportunities for sustainable urban development. These new surfaces become canvases for innovative urban planning, setting the stage for multifunctional spaces that enhance city living.

### *Space Utilization and Infrastructure*

- **Maximized Land Use:** In densely populated urban settings, where land is at a premium, lids provide additional space, effectively turning air rights into usable real estate. This can pave the way for diverse developmental projects without further land acquisition.
- **Diverse Infrastructural Opportunities:** The strength and versatility of these lids allow for a range of structures to be built atop them. The possibilities are expansive, from parks and recreational spaces to commercial establishments, residential buildings, parking lots and public amenities.

### *Economic Boost and Investment Opportunities*

- **Attracting Investments:** The development of these spaces can attract private investments, leading to public-private partnerships that can offset some of the costs of lidding projects.
- **Job Creation:** Construction, maintenance, and the businesses that emerge on these lids generate employment opportunities, contributing positively to the local economy.
- **Increased Property Values:** Adjacent areas often see a surge in property values due to the enhanced aesthetics and functionality of the newly developed space.

### *Equity, Community Connection and Cohesion*

- **Multi-Modal Corridors:** With regional through-traffic tucked below the lid, there is ample space for multi-modal corridors to accommodate safe and equitable mobility options such as pedestrian pathways, protected bike lanes and dedicated transit-ways, in addition to the potential for low-speed vehicular traffic.
- **Integrated Transportation Nodes:** Some lidding projects incorporate public transport hubs, like bus stops or metro stations, ensuring a seamless transit experience for residents.
- **Connecting Divided Areas:** Lidding projects can reunite neighborhoods and areas previously separated by motorways or highways, fostering greater community cohesion.

### *Social and Cultural Hubs*

- **Community Centers:** Lids can host community centers, libraries, or other public amenities, fostering community engagement and cultural exchange.
- **Recreational and Green Spaces:** Parks, playgrounds, and open spaces on lids offer urban dwellers a respite from the concrete jungle, promoting physical health and mental well-being.
- **Events and Gatherings:** These spaces can become focal points for local events, markets, festivals, and performances, fostering a vibrant community life.

### **Environmental Advantages**

The environmental benefits of highway lidding stretch beyond aesthetics. By incorporating these structures, cities can work towards a more sustainable and resilient future, addressing several environmental challenges urban sprawl poses.

#### *Reduction of Noise Pollution*

- **Acoustic Shielding:** The lid shields the highway traffic noise effectively from the environment. This results in quieter neighborhoods, reduced healthcare costs, higher productivity and improved overall well-being for residents.
- **Integrating Noise Absorbing Materials:** Modern lid designs often incorporate materials that reduce noise in the portal areas and in open stretches (see Figure 2).

#### *Improved Air Quality*

- **Green Barriers:** By landscaping lids with trees and greenery, they serve as natural filters, capturing particulate matter and converting pollutants into cleaner air through photosynthesis.
- **Ventilation:** A lid improves the air quality by shielding the neighborhood from road emissions. Increased concentrations at the portals are generally below acceptable threshold levels, since the natural ventilation induced by the moving traffic is sufficient. A mechanical ventilation can provide tenable conditions in extraordinary situations, namely when a fire under the lid occurs. For very long highway lids, adequate ventilation measures such as portal exhaust and filters can improve the air quality in the portal regions.
- **Green Barriers:** By landscaping lids with trees and greenery, they serve as natural filters, capturing particulate matter and converting pollutants into cleaner air through photosynthesis.

#### *Urban Heat Island Effect Mitigation*

- **Cooling Green Spaces:** Plants and trees on the lids can reduce the urban heat island effect, a phenomenon where urban areas experience higher temperatures than their rural surroundings. Vegetation provides shade and releases moisture, naturally cooling the surrounding area.

- **Reflective and Cool Roofing Materials:** Incorporating materials that reflect sunlight, instead of absorbing it, can further mitigate heat buildup.

#### *Enhancing Biodiversity and Providing Habitats*

- **Urban Ecosystems:** Lids landscaped with diverse flora can attract and sustain various fauna, essentially becoming urban biodiversity hotspots.
- **Corridors for Wildlife:** Strategically placed green lids can act as corridors or bridges for urban wildlife, reducing the risk of road deaths and promoting ecological connectivity.

#### *Water Management and Conservation*

- **Rainwater Harvesting:** Implementing rainwater harvesting systems on highway lids is a proactive step toward climate resilience. These systems collect and store rainwater, reducing reliance on external water sources. In regions susceptible to erratic rainfall patterns and flash storms, such as those driven by climate change, rainwater harvesting provides a dependable water source while mitigating the risk of flooding associated with heavy precipitation.
- **Green Infrastructure to Manage Flash Storms:** Incorporating green infrastructure elements, such as permeable surfaces and bioswales, plays a vital role in managing the challenges of flash storms. Flash storms can overwhelm conventional drainage systems, leading to urban flooding. However, highway lids designed with permeable surfaces allow rainwater to infiltrate naturally, reducing rapid runoff. Bioswales, in turn, aid in the filtration and absorption of rainwater, enhancing water quality while lessening the burden on stormwater systems.

#### **Road Safety and Operation**

Road tunnels and lids provide a safer and more sustainable route than open roads. According to statistical data, the accident rate in tunnels is lower than on open roads. Drivers are shielded from distraction and unfavorable environmental conditions, for instance, sun glare, rain, and ice. Moreover, tunnels prevent collisions by eliminating conflicts with pedestrians and animals crossing

Shielding from harsh environmental conditions also protects the roadway structure. The lifetime of tunnels is usually longer than that of other infrastructure, such as bridges, and roadway surfaces need to be renewed less often than on open roads (e.g., PIARC 2008 and 2023).

## KEY CONSIDERATIONS IN HIGHWAY LIDDING

While offering substantial advantages, highway lidding is complex and demands meticulous planning and foresight. Ensuring the success and longevity of such projects requires addressing a range of technical, financial, environmental, and social considerations.

### Technical and Structural Integrity

- **Highway Continuity:** The main purpose of the highway, to provide a safe road connection, must not be impaired by the lid construction. Lane and shoulder widths should be maintained. In fact, the lid may even improve road safety, as is explained below.
- **Load Bearing Capacity:** One of the foremost considerations is ensuring the lid can support the intended structures or greenery above while allowing safe passage for vehicles below. This necessitates rigorous structural engineering assessments.

During the planning stage, it is critical to determine the planned use of the lid, both in terms of initial intended use and any longer-term anticipated use. The use of the tunnel is a driving factor in establishing the appropriate dead loads and superimposed loads for which the lid and supporting structure must be designed for. Careful selection of the loading criteria in the planning stage allows for eventual flexibility where it may be needed in the future.

Additionally, the project location or the intended use of the lid may require establishing loads (magnitudes and load factors) that are not currently covered by codes, which were developed for tunnels where substantial earth loads or water pressure are the governing loads. For example, the *AASHTO LRFD Road Tunnel Design and Construction Guide Specifications* (AASHTO) do not currently have provisions for snow loads, which may be a substantial load condition on lids with park settings in cold climates. Similarly, AASHTO LRFD does not currently have provisions for buildings. Depending on the intended use of the lid, project-specific loads and load combinations may need to be established to account for planned development or intended use.

- **Drainage and Weather Implications:** Managing rainwater drainage, snow loads, and other weather-related challenges is pivotal to the lid's longevity and functionality.

Structural durability and minimizing future maintenance are core concerns of all transportation authorities. Urban lid projects provide new challenges with regard to structural detailing to maximize service life. With lids more prone to freeze-thaw cycles than deeper tunnels, proper drainage design becomes paramount. In addition to sloping a lid to maintain a minimum pitch to drain, a lid cross-section should include well-draining fill materials, drainage layers, and waterproofing membranes. Where the planned use for the lid is in a park setting to include plantings, a concrete protective layer is recommended on top of any drainage and insulation layers to help minimize the risk of roots entering and clogging drainage layers. Such a protective layer also helps prevent unintended damage of the drainage layers from digging for placement of new or replacement plantings.

Boxes for planting are often considered in lids with parks to minimize dead loads. However, such boxes typically create low points prone to water collection. Sharp corners in these boxes can be challenging to appropriately waterproof. Special considerations to avoid or soften such details may help establish more durable solutions.

### Financial Implications

- **Initial Capital Costs:** High-quality lidding projects demand significant upfront investment. Determining sources of funding—whether public, private, or a combination—is crucial.
- **Maintenance Costs:** Beyond the initial construction, regular upkeep of both the structural aspects of the lid and any amenities atop it can accrue considerable expenses.
- **Economic Return:** To justify the costs, assessing the potential return on investment through increased property values, business opportunities, reduced healthcare costs, and other economic boosts.

## Regulatory and Legal Hurdles

- **Land and Air Rights:** Especially in densely populated urban centers, navigating the intricacies of land ownership, air rights, and zoning regulations is a fundamental step.
- **Permitting and Approvals:** Such large-scale projects typically require a plethora of permits and approvals from various municipal and state agencies, necessitating careful coordination.

## Environmental and Social Impact

- **Environmental Assessments:** Before construction, understanding the potential environmental impacts, including on local ecosystems and water tables, is essential.
- **Community Engagement:** As these projects reshape urban landscapes, soliciting feedback and buy-in from local communities ensures that the resultant development aligns with their needs and aspirations.
- **Cultural and Heritage Considerations:** In areas with historical or cultural significance, the design and execution of lidding projects must be approached with sensitivity.

## Noise

Noise protection is a key feature of urban lids. Noise absorption panels at the tunnel portals and along open stretches are essential to reduce the noise impact in those areas.



**Figure 2** Tunnel portal with absorptive noise protection panels

## Air quality

In the past, vehicle emissions substantially impaired air quality adjacent to highways, leading to health issues like respiratory diseases. Nowadays, vehicle exhausts generate very low emissions, which will even decrease further with the increasing use of electric cars. Dust particles and tire and brake abrasion are becoming more critical for road air quality than motor exhausts.

While the lid shields the environment from vehicle emissions, noxious substances may be concentrated at the exit portal. However, due to dilution by the airflow, which is induced by the piston effect of moving vehicles, the concentrations are below the allowable threshold in most tunnels. Tunnel ventilation is required only in extraordinary cases, namely during long-lasting congestion and motorists failing to switch off their engines, and for fire ventilation.

Reducing emissions at tunnel portals may be useful in very long tunnels. For that, the tunnel air is exhausted and blown vertically into the atmosphere, where it is diluted below admissible concentrations. In a few projects, the exhausted tunnel air is treated by filters. The usefulness and application of such measures must be assessed with a diligent engineering analysis based on realistic emission data and traffic modeling.

## Safety

Collisions impose the most significant risk to drivers on roads. Fires in road tunnels happen less often than collisions but may impose a serious hazard to road users who are trapped in the smoke inside the enclosed underlying structure. A fire with an extraordinary heat release rate, e.g., burning Flammable Liquid Cargo (FLC), might result in substantial damage and even partial collapse of the lid structure.

The probability of a collision or fire hazard on a defined road section directly correlates to its length and traffic load. Usually, the collision risk in tunnels is lower than on open roads, and the probability of collisions is a magnitude higher than that of vehicle fires (e.g., Pospisil, 2011). To a large part, the risk is related to driver behavior and vehicle conditions, which can only partly be influenced by safety measures on the road infrastructure.

- **Preventive safety measures** are most efficient from a cost-benefit point of view:
  - Road alignment, considering traffic density, line of sight, lane and shoulder width.
  - Most urban highway lids provide unidirectional traffic, with a separation wall between roadways.
  - Speed limit adequate to sight distance and traffic conditions.
  - Traffic management with signals and barriers for lane or tunnel closures.
  - Traffic management in the adjacent road network.
  - Lighting, which is directly related to the allowed speed and sight distance, incl. floor guidance lights.
- **Fire Life Safety** measures are described in several NFPA standards (e.g., NFPA 502, 2023 or NFPA 55, 2022)) and depend on the tunnel length and type of expected vehicle fire, e.g., whether FLC vehicles are allowed. Such measures may include:
  - Smoke and fire detection.
  - Structural fire protection and/or active fire suppression systems, depending on a risk assessment and expected costs for tunnel closure and refurbishment after a large fire.
  - Standpipes with fire department connections and fire fighting water supply.
  - Longitudinal tunnel ventilation with flow control for smoke management (see Pospisil, 2020).
  - For very long tunnels with regular congestion, additional point smoke exhaust by controllable dampers in short intervals may be adequate (e.g., Pospisil 2020).
- **Egress and Ingress Routes:** Designing clear, accessible egress and ingress routes for scenarios like vehicle breakdowns, accidents, or fires on the highway beneath the lid is paramount. A critical planning factor is ensuring that emergency services can quickly reach any point on or beneath the lid.
- **Regular Inspection, Testing, and Maintenance:** Since the atmosphere in the tunnel can be wet and corrosive, the protection of the tunnel structure and equipment from corrosion and regular inspection is essential. All tunnel systems must be maintained and regularly tested.

## Estimating of Costs and Funding Sources

- **Feasibility Studies:** Before embarking on the project, detailed feasibility studies can offer preliminary cost estimates, helping stakeholders understand the financial scope.
- **Itemized Budgeting:** Breaking down the budget into specific items — from raw materials to labor, from consultancy fees to contingency funds — provides clarity and helps in financial planning.

- **Public Funding:** Investigate potential funds from city, state, or federal levels. Grants or subsidies might be available for projects that align with broader urban development or environmental goals, such as the United States Department of Transportation’s Reconnecting Communities and Neighborhoods Program discussed earlier.
- **Private Investment and Partnerships:** Exploring public-private partnerships can provide significant financial boosts, especially if the lidding project offers commercial opportunities.
- **Special Funding Tools:** Value capture revenue tools such as Tax Increment Financing (TIF) use tax on future gains in real estate to pay for public improvements such as infrastructure.

### Impact on Current Traffic and Traffic Management During Construction

The very nature of highway lidding means working over or near active traffic lanes. This necessitates understanding and managing the potential disruptions.

- **Short-term vs. Long-term Impact.** While some disruptions might last just a few hours or days, others could span weeks or even months. An understanding of the timeframes is essential for planning.
- **Off-peak Construction.** To minimize disruptions, significant construction activities might be scheduled during off-peak hours or weekends when traffic volumes are lower.
- **Traffic Redirection.** To facilitate construction, traffic might need to be rerouted. Effective communication of these changes to the public is crucial to prevent confusion and congestion.
- **Infrastructure Support.** Temporary ramps, bridges, or lanes might need to be constructed to manage traffic flow during the lidding process.
- **Barricades and Signage.** Marked barriers and signs are essential to guide traffic safely around construction zones.
- **Speed Limits.** Reduced speed limits might be enforced around construction areas to ensure the safety of both the drivers and the construction crew.
- **Re-routing of Hazardous Goods Transport.** Due to the increased risk on the construction areas, hazardous goods and flammable liquid cargo may need to be temporarily re-routed.
- **Communication with the Public, Regular Updates:** Using media, social platforms, and dedicated project websites to provide regular updates on construction progress and traffic changes can help mitigate commuter frustrations.
- **Communication with the Public Feedback Channels:** Establishing channels for public feedback can provide insights into unforeseen traffic challenges and offer improvement opportunities.

### Sustainable Construction and Eco-Friendly Approaches

In today's urban landscape, infrastructural growth and environmental conservation intersections are more pronounced than ever. Highway lidding projects present a unique opportunity to champion sustainable construction methodologies that prioritize the environment, which in turn benefits the local community.

A key component of this eco-friendly approach is material selection. Projects can substantially reduce their environmental footprint by prioritizing recycled construction materials or locally sourced ones.

The primary construction material is concrete, the production of which requires a high energy demand. Therefore, reducing the amount of concrete by optimizing the lid concept directly reduces the ecological footprint. An example of such a measure is to provide longitudinal ventilation instead of transversal ventilation, which would require ventilation ducts and fan buildings, as in older tunnels.

With longitudinal ventilation, the fans rarely need to be in operation. Transversal ventilation would bring about massive energy consumption because it slows down the natural ventilation induced by the piston effect of moving vehicles (e.g., Pospisil 2020).

Energy efficiency extends beyond the completed project; it begins during construction. Using green machinery powered by electricity or more energy-efficient ones can dramatically curb emissions during the construction phase. Moreover, by optimizing transportation and logistics, materials can be moved more efficiently, reducing fuel consumption and the associated environmental impact.

Waste management is another crucial facet. Emphasizing the reduction of waste at its source and facilitating the recycling of construction debris might reduce landfill contributions. Moreover, ensuring the responsible disposal of hazardous waste in adherence to environmental guidelines safeguards both the environment and the community.

The integration of nature into highway lidding projects serves multiple purposes. Green roofs and vertical gardens enhance aesthetic appeal and offer functional benefits like improved insulation, stormwater management, and air quality enhancement. Considering the global push towards renewable energy, including solar panels or photovoltaic cells in the lid's design can transform these structures into hubs of clean energy generation.

Water, a resource growing scarcer in many regions, must be used judiciously. Employing sustainable water use practices during construction, such as rainwater harvesting, can ensure this vital resource is conserved. Furthermore, designing sections of the lid with permeable surfaces can play a pivotal role in groundwater recharge and effective stormwater management.

In essence, the sustainable construction and eco-friendly approaches in highway lidding are not just about building for today but ensuring that these infrastructural marvels stand as testaments to a future where urban development and environmental stewardship go hand in hand.

## RECENT EXAMPLES

### **Klyde Warren Park, Dallas Texas**

One interesting example of lidding over an urban roadway is Klyde Warren Park (KWP) in Dallas, TX, completed in 2012. KWP is a 5-acre park decked over the 8-lane Woodall Rodgers freeway. While this paper has briefly discussed lidding or tunneling, KWP is in fact both. The length of the lidding, nearly 1,200 linear feet of freeway enclosed by the deck, necessitated ventilation and fire life safety, and thereby considered a tunnel.

The costs were approximately \$110 million, funded by public-private partnership. This included \$20 million in bond funds from the City of Dallas, \$20 million in highway funds from the state and \$16.7 million in stimulus funds. The balance of funding is through individual donors directly to the Woodall Rodgers Park Foundation. The park is estimated to have created \$312.7 million in economic benefits. From 2012 –2015, lease rates increased from 32-64% nearby. Due to its great success, in 2021, the City Council unanimously voted to expand the tunnel to provide an additional 1.3 acres of public space, extending the tunnel to 1662 ft (see W4, 2013).



Figure 3: Klyde Warren Park

### Bored Tunnels in the US and Abroad

Most long urban tunnels in the US are not lids, but bored tunnels, however the same arguments for bringing road traffic underground apply. One example is the above mentioned Boston Central Artery Tunnel project. In Seattle, the SR99 Alaskan Way Viaduct was an elevated highway along the waterfront. By constructing a 1.8 mile long bored tunnel, which was opened in 2019, the highway was brought underground, and the waterfront restored.

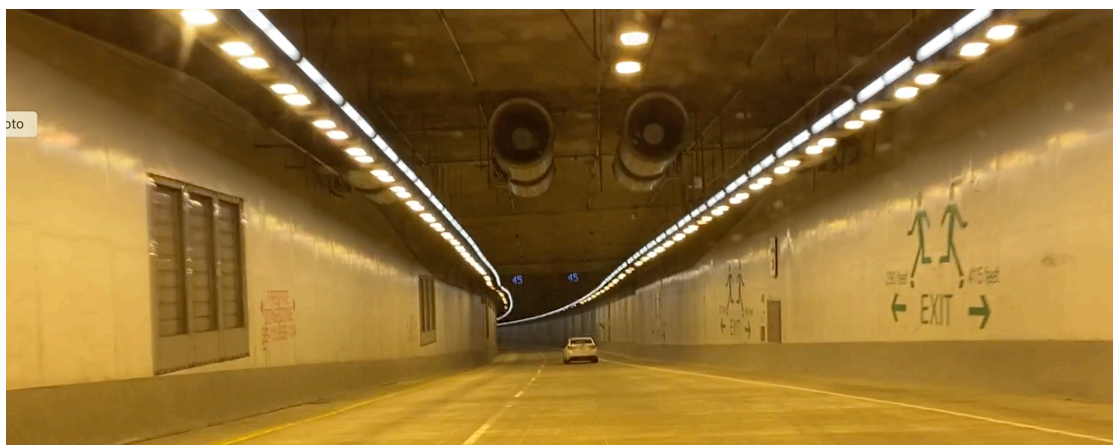


Figure 4: Inside the SR99 Tunnel, Seattle

An example from Switzerland is the Nordtangente Basel on the highway A3. The urban highway, built in the 1950s, cut through residential areas, causing the above described detrimental effects. After 30 years of planning, it was decided to bring the highway underground, consisting of two tunnels with several ramps and a bridge over the River Rhine in between, which is enclosed for noise protection. The total length is 2 miles. Over the tunnels, there are local roads, tramways and pedestrian walkways. It took 13 years to build in a dense urban environment under traffic, at costs of 1.55 billion Francs – in terms of costs per length the most expensive road ever built in Switzerland. The tunnel was opened in 2007.

The tunnels are equipped with a longitudinal ventilation system with jet fans and sophisticated feedback flow control. When the ventilation was originally designed in the early 1990s, ventilation shafts at each portal were foreseen to exhaust the contaminated tunnel air, to prevent it from spreading around the portal areas. However, due to decreasing vehicle emissions, only one shaft was built, which had never been in operation. The obsolete shaft was finally demolished in 2018.



**Figure 5: Obsolete Ventilation Shaft of Nordtangente Tunnel, Basel, Switzerland**

Actual international examples of long urban highway tunnels are mostly bored and/or cut & cover tunnels, not lids:

- Spain, Madrid M30, multiple tunnels, the longest over 6 km, completed in 2008
- Singapore Kallang–Paya Lebar Expressway, 10 km tunnel length, completed in 2008
- France, Paris A86, 10 km & 5.5 km, completed in 2011
- Japan, Yamate tunnel, total 18.2 km tunnel, constructed from 1992 to 2015
- Czech, Prague Blanka tunnel, 5.5 km, opened in 2015
- Australia, Sydney Westconnex tunnel network with a total 26 km tunnel length under construction
- Sweden, Stockholm Bypass, 18 km tunnel under construction

## **FUTURE DIRECTIONS AND POTENTIAL**

### **The Broader Scope: Integrating with Other Urban Revitalization Initiatives**

Highway lidding and tunneling should not be seen in isolation. It's a component of the larger urban fabric and should integrate seamlessly with other urban revitalization efforts. This may include connecting lidded areas with pedestrian-friendly zones, creating green corridors that link parks, or designing multi-modal transport hubs that enhance mobility. Integrating these progressive highway projects with initiatives like urban farming, community gathering spaces, or cultural hubs can create vibrant, multifunctional spaces that truly revitalize urban landscapes.

## Potential Challenges and Solutions for Future Implementations

- **Financing.** The most significant challenge for highway lidding projects is securing adequate financing. While the initial capital costs are substantial, the long-term economic and societal benefits can justify the investment.  
**Solution.** Public-private partnerships can be explored more aggressively. The generated revenue can offset a significant portion of the construction costs by offering commercial development rights atop or around the lidded sections. Another avenue is leveraging land value capture mechanisms, where the increase in land and property values resulting from the project can be channeled back into financing the project itself.
- **Healthcare Costs.** With improved air quality and reduced noise pollution, there's potential for significant savings in public healthcare costs. Reduced respiratory issues, mental health benefits from greener spaces, and lower stress levels can lead to substantial taxpayer savings.  
**Solution.** An argument can be made for redirecting a portion of these savings back into the project. A model where future healthcare savings are projected, and a fraction is earmarked for lidding projects can be explored.
- **Construction Disruptions.** Building a lid over an active highway is bound to cause disruptions. The longer the construction period, the greater the inconvenience to the general public and potential economic losses due to traffic delays.  
**Solution.** Advanced construction techniques, like pre-fabricated sections or off-site construction, can speed up the on-site assembly process. Implementing night-time construction, offering alternative routes, or providing incentives for off-peak travel can minimize disruptions. All tunnel systems must be pre-assembled and tested before being installed in the tunnel to minimize commissioning and testing time. Effective communication with the public, perhaps through digital platforms providing real-time updates, can help manage expectations and reduce frustrations.

## CONCLUSION

### Recap of Key Findings and Discussions

Urban highway lidding and tunneling present a transformative solution to urban challenges, bridging the divide created by highways and fostering community growth. Its multidimensional benefits encompass enhanced urban aesthetics, efficient land utilization, and potential green spaces that rejuvenate city landscapes. Technically, while promising, it requires meticulous planning in areas of structural integrity, drainage, and safety measures. Financial implications, both initial and long-term, and regulatory complexities underline the enormity of undertaking such projects. Furthermore, integrating sustainability in design and construction is a key takeaway, emphasizing the synergy between urban development and environmental stewardship.

### The Path Forward: Embracing Urban Revitalization through Highway Lidding and Tunneling

As urban centers continue to grow and evolve, the push towards more inclusive and sustainable designs will be paramount. Although financially challenging, highway lidding offers a unique opportunity to merge urban planning with environmental restoration. The collaboration of public and private entities and community engagement will be crucial to realize future highway lidding projects. With continuous advancements in design and technology, the future of highway lidding promises a harmonious blend of urban renewal and ecological mindfulness.

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