

A STUDY ON MANHOLE COVER RENOVATION, ROAD SAFETY AND URBAN AESTHETICS



Assoc. Prof. Dr. Alper Sağlık^{1, a, *} - Graduate Student Aslihan Uygun^{2, b}

¹ Çanakkale Onsekiz Mart University, Faculty of Architecture and Design,
Department of Landscape Architecture, Çanakkale – Türkiye

² Çanakkale Onsekiz Mart University, Graduate Education Institute,
Landscape Architecture Department, Çanakkale – Türkiye

*Corresponding Author:
E-mail: alpersaglik@gmail.com

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a:  ORCID 0000-0003-1156-1201, b:  ORCID 0009-0002-0193-4481

ABSTRACT. Manhole covers are essential components of urban infrastructure, contributing to the operation, safety, and aesthetics of cities. Their proper design, installation, and maintenance ensure access to services such as water, sewage, and telecommunications, while supporting road safety and urban sustainability. This study evaluates the challenges posed by manhole covers, including noise, vibration, driving discomfort, and infrastructure damage due to improper alignment or material wear. Advanced materials and technologies such as smart covers equipped with sensors are explored for their ability to improve safety, aesthetics, and environmental sustainability. The renewal of manhole covers on the Kepez route is analyzed, highlighting improvements in alignment, durability, and urban coherence. Standards from Turkey and other countries are compared, emphasizing the significance of innovative designs and eco-friendly materials in manhole cover applications. Recommendations include adopting smart technologies, environmentally sustainable materials, and culturally enriched designs to enhance urban identity and infrastructure efficiency. These findings provide a framework for future projects, aligning urban transformation goals with technological advancements and aesthetic considerations.

Keywords: *manhole covers, road safety, urban aesthetic, infrastructure maintenance, traffic accidents*

Abbreviations

M.C. Manhole Cover

INTRODUCTION

Manhole covers play a critical role in the functioning of cities' infrastructure systems. By providing access to services such as water, sewage, electricity and telecommunications, manhole covers enable the safe operation of these systems and contribute to the sustainability of the infrastructure [1]. In areas with dense urbanization, the production of durable, safe and functional manhole covers is of great importance for the smooth operation of urban infrastructure [2]. In addition, these covers provide secure access to infrastructure networks for maintenance and repair, enabling long-lasting and effective management of infrastructure.

The impact of manhole covers on road safety is also significant. When properly installed and regularly maintained, they provide a safe environment for motorists, cyclists and pedestrians. However, misaligned or damaged manhole covers can cause accidents. In particular, covers with slippery surfaces pose a serious risk to two-wheeled vehicle

users in wet weather conditions. For example, a study in Taiwan found that old manhole covers have low skid resistance, threatening road safety [3].

Aesthetically, manhole covers are an important part of urban architecture. In modern cities, manhole covers that are environmentally compatible and aesthetically designed not only support the functionality of the infrastructure, but also add value to urban aesthetics. Manhole covers that reflect the city identity by being decorated with local motifs contribute to the urban fabric and strengthen environmental harmony. Examples in Japan, where manhole covers are designed like works of art to reflect the cultural identity of the city, show the value that aesthetic design can add to urban life [4]. Similarly, when designed correctly, manhole covers can strengthen urban aesthetics and identity with their orientation and guidance functions [5].

In recent years, with the development of smart city technologies, innovative solutions such as NB-IoT-based smart manhole covers have set new standards in infrastructure management. These systems facilitate infrastructure management by enabling rapid intervention in cases where manhole covers are displaced, damaged or stolen. They also provide a safe and efficient infrastructure system by instantly monitoring parameters such as pressure, water level and gas density on the cover [2].

The aim of this study is to examine the importance of manhole cover replacement and to investigate the standards and approach to these covers in Turkey and foreign countries. Specific to the renovation of manhole covers on the Kepez route, the aesthetics and safety of these covers will be evaluated. In this context, suggestions on how to design better, safer and more aesthetic manhole covers will be presented. The study aims to draw attention to the importance of manhole covers within the framework of urban infrastructure sustainability, road safety and urban aesthetics, and to emphasize the integration of smart city technologies into this process.

MATERIALS AND METHODS

Problems Caused by Manhole Covers

Although manhole covers are indispensable elements of urban road infrastructure, they can cause various problems if they are improperly installed or dislodged over time. These covers can interact with vehicles, causing vibration, noise, impaired driving comfort and infrastructure damage. Such problems are particularly pronounced with heavy traffic, improper installations or the use of wearing materials.

Vibration and Noise

Improper positioning of manhole covers can cause vibration and noise when vehicles pass by. In particular, metal manhole covers, when misaligned or loose, can shake in their sockets as vehicles pass by, creating a loud noise. This is particularly noticeable in areas where heavy vehicles pass by and can disturb residents. According to studies, the misalignment of metal gates to the road surface leads to increased noise levels along the road, which can negatively affect the environment [6]. Plastic reinforced gates can reduce such noise through better alignment and vibration absorbing properties [7]. It is emphasized that such noises may cause discomfort to drivers, especially in heavy traffic areas, and may threaten traffic safety in the long term by reducing driving comfort [8].

Deterioration of Driving Comfort

When manhole covers are not positioned properly or become loose, they can cause unstable movement of vehicles while driving. A vehicle traveling at high speed may be forced to move abruptly when it notices the height difference in the manhole cover. Such irregularities can distract the driver and lead to increased accidents. In addition, this can also damage the suspension systems of vehicles, increasing maintenance costs [9]. The subsidence and elevation of the road surface around the cover can negatively affect driving comfort, causing the driver to lose control of the road. In particular, height differences of more than 5 cm can cause serious discomfort while driving and may distract the driver by impairing travel comfort [10].

Infrastructure Damages and Water Accumulation

Manhole covers can cause serious damage to road infrastructure when they are improperly installed or dislodged over time. Metal covers transfer vehicle loads directly to the surrounding ground, which can lead to cracks and subsidence zones in the road surface. This can lead to water seepage into the road infrastructure, triggering serious problems such as erosion and subsidence [7]. In addition, especially in areas where puddles form, the road surface becomes slippery, threatening driving safety. In wet weather conditions, failure to properly drain water can lead to the formation of puddles on the road surface, restricting the driver's visibility [4]. Furthermore, over time, these puddles can cause the road to collapse or asphalt to deteriorate, increasing infrastructure costs. In freeze-thaw cycles, accumulated water can lead to cracking of the road surface and accelerated infrastructure damage [11].

The installation and maintenance of manhole covers play a critical role for the sustainability of road infrastructure. Vibrations and noise can be a nuisance for surrounding residents, while infrastructure damage and ponding can lead to greater problems in the long term. To mitigate such problems, proper material selection and placement methods are essential, as well as the integration of proper drainage systems to drain water properly. Plastic composite covers are expected to contribute to solving such problems with their better alignment and vibration absorbing properties compared to metal covers. In this way, both driving comfort can be improved and road infrastructure can be protected.

Inspection and Renewal of Manhole Covers

Regular inspection and renewal of manhole covers, a critical component of urban infrastructure, are essential for safety, sustainability, and long-term durability. Traffic intensity, environmental factors, and gradual deformations necessitate continuous monitoring and timely replacement of these covers. This process aims to build a more efficient and sustainable infrastructure by integrating technical standards, innovative materials, and modern technologies.

Importance of Regular Inspection and Maintenance

The regular inspection of manhole covers is a critical requirement for infrastructure resilience and road safety. Kaddoura et al. [12]. highlight that routine inspections enhance cover durability and enable rapid intervention in case of damage. The inspection process should thoroughly analyze issues such as cracks, fractures, and water tightness of the covers. However, the current inspection models, often limited to peak and average scores, may fall short in decision-making processes [13]. Developing comprehensive and

modern evaluation models allows for more accurate and reliable decisions in infrastructure management.

In heavily trafficked areas, the alignment of manhole covers significantly affects road safety and driving comfort. Xinyu et al. [15] state that proper alignment prevents vibration-related problems and improves the driving experience. Regular monitoring of surface roughness is recommended to enhance the durability of covers and prevent vibration-induced degradation [8].

Modern inspection techniques leverage technology to achieve more effective results. For example, RFID tags can be used to automatically identify manhole covers and quickly detect damages. This technology contributes significantly to the efficient management of large infrastructure systems [14].

Renewal Process and Technical Details

Renewing manhole covers involves not only addressing existing damages but also incorporating more durable, eco-friendly, and modern materials. During renewal efforts, aspects such as water-tight seals, sinking issues, and surface durability should be carefully evaluated. Kaddoura and Zayed (2018) [12] emphasize that considering these technical details increases the functionality and longevity of the covers.

Modern renewal methods include aligning covers with road surfaces using resin cement, a technique that reduces infrastructure costs and allows for quick re-opening to traffic [19]. Additionally, using image processing and data analytics technologies, manhole covers can be scanned in 3D. This allows for precise identification of damaged areas, facilitating prioritized repairs [20]

The use of eco-friendly materials is a vital aspect of making the renewal process more sustainable. Suffo et al. [17]. highlight that covers made of HDPE, GFRP, and recycled materials are resistant to corrosion and have reduced theft risks. Recycled HDPE covers stand out not only for their economic advantages but also for their resistance to environmental conditions [18].

Modern cover designs focus on enhancing water-tightness and protection against environmental impacts. Covers made with innovative materials aim to improve durability in areas with heavy vehicular traffic and industrial zones. Furthermore, manhole covers equipped with smart sensors enhance safety and automate maintenance processes [14].

Technical Standards and Applications

The technical standards used during the inspection and renewal of manhole covers directly affect the efficiency of the process. In Turkey, the TS EN 124-2 standard provides a definitive framework for the design and use of manhole covers. This standard classifies covers based on their usage areas and load capacities:

- Class A 15: Suitable for pedestrians and cyclists.
- Class D 400: Designed for heavy vehicle traffic on highways.
- Classes E 600 and F 900: Developed for high-load requirements in airports and industrial zones [21].

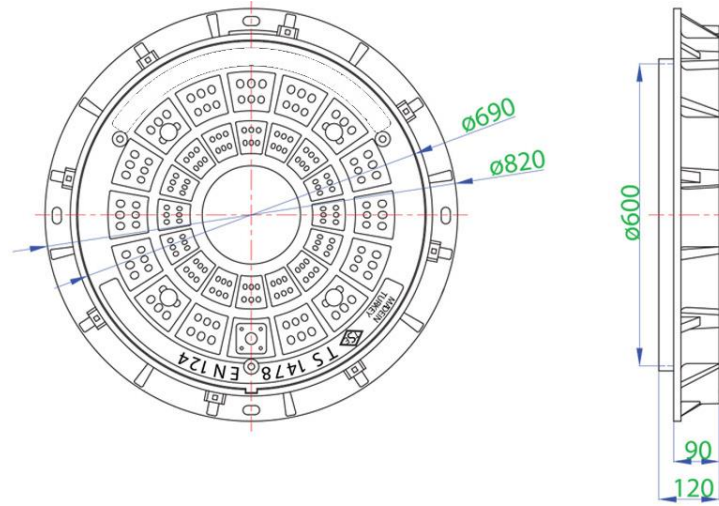


Fig. 1. 600 mm Non-Hinged Manhole Cover Technical Drawing (Compliant with TS EN 124 Turkish Standards)

Standard measurements for manhole covers are typically determined based on circular covers with a 600 mm diameter and rectangular covers measuring 900×600 mm. The durability of these covers is enhanced by the materials used and their coating properties. In Turkey, cast iron covers are commonly preferred, though composite materials have begun to be utilized in modern projects [25].

Standards in Foreign Countries

The EN 124 standard used in Turkey is frequently referenced in the design of manhole covers in other countries. However, some nations have developed unique standards tailored to their local needs:

- **United States:** Manhole covers are classified according to the AASHTO M306 standard, which focuses on heavy vehicular load resistance and compliance with dynamic testing methods [22].
- **Japan:** The JIS G5502 standard is applied to manhole covers, prioritizing high corrosion resistance and earthquake safety [23].
- **China:** The GB/T 23858-2009 standard in China is similar to EN 124 but includes specific local adaptations in material specifications and testing requirements.

Comparison of Standards: Turkey and Other Countries

The EN 124 standard used in Turkey aligns fully with European countries and provides a comprehensive framework for load capacity classification. Conversely:

- The **AASHTO M306 standard** in the United States emphasizes dynamic loads.
- Japan focuses on **earthquake safety and aesthetic elements** in its manhole covers.
- China adds **local modifications** to the EN 124 standard, tailored to its economic and industrial requirements.

Environmental and Technical Contributions

The design of modern manhole covers increasingly emphasizes environmentally friendly materials and innovative technological solutions:

- In Turkey, manhole covers made of recycled HDPE offer long-lasting solutions, contributing to environmental sustainability [17].
- In other countries, sensor-enabled **smart manhole covers** not only enhance safety but also simplify infrastructure management [14].

CONCLUSION AND DISCUSSION

This study thoroughly examines the contributions of road renewal projects to urban life in terms of safety and aesthetics, as well as the outcomes of implementations along the Kepez route. The analysis of the impacts of road renewal technologies and the changes made to manhole covers on the Kepez route reveals how these processes affect the urban fabric. The subsections below aim to evaluate the current situation and provide guidance for future studies.

Contributions of Renewal to Road Safety and Urban Aesthetics

Improvements in Road Safety

Road renewal projects significantly enhance road safety. Polymer concrete manhole applications offer advantages over traditional cement concrete, such as chemical resistance, durability, and reduced maintenance requirements, thereby improving road safety [26]. For example, in areas like Austin, Texas, projects using such materials have provided long-lasting safety solutions, ensuring safer vehicle passage.

Modern renewal methods, such as trenchless technologies, minimize surface disruptions, maintain traffic flow, and prevent accidents [27]. Specifically, manhole cover renewals carried out using No-Dig technology have prevented surface damage and improved driving comfort. Additionally, innovative solutions like smart manhole covers contribute to road safety by enabling instant intervention in issues such as water overflow and underground gas accumulations [29].

Organized Appearance from an Aesthetic Perspective

Urban aesthetics have been positively affected by road renewal projects. The durability of polymer concrete reduces the frequency of maintenance and repairs often required by cement concrete, minimizing aesthetic disruptions. This has led to roads achieving a clean and organized appearance [26].













Moreover, manhole covers renewed with epoxy and polymeric coatings have been made more harmonious with their surroundings, creating visual coherence in urban areas. Additionally, environmentally friendly designs, such as integrating green spaces, have enriched urban aesthetics [29]. Trenchless renewal processes also prevent surface disruptions, preserving the existing urban fabric and offering an aesthetically pleasing appearance [27].















Detailed Assessment of Manhole Covers on the Kepez Route

The evaluation of manhole covers on the Kepez route, considering both their previous and renewed states, has been conducted in terms of their contributions to safety and

aesthetics. The table below summarizes the impacts of the renovations for each manhole cover.

Table 1. *Old and New Versions of Manhole Covers on the Kepez Route*

Manhole Cover No	Former Version	Updated Version
M.C.1		
M.C.2		
M.C.3		
M.C.4		
M.C.5		
M.C.6		

M.C.7		
M.C.8		
M.C.9		
M.C.10		
M.C.11		
M.C.12		
M.C.13		



The renewal efforts for manhole covers on the Kepez route have brought significant improvements in terms of safety and aesthetics. As seen in Table 1, manhole covers such as M.C.1, M.C.2, M.C.4, and M.C.6, which protruded above the road surface, caused vibrations in vehicles and disrupted traffic flow. During the renewal process, these covers were adjusted to align with the road level, enhancing safety for both vehicles and pedestrians. Additionally, adjustments around these covers yielded positive outcomes in terms of safety and aesthetics.

As listed in Table 1, manhole covers like M.C.3, M.C.5, M.C.9, and M.C.11 caused discomfort during vehicle crossings and created visual inconsistencies due to surrounding surface damage. These issues were resolved through the renewal process, which not only improved transit safety but also gave the road a clean and orderly appearance. The renewed covers now align aesthetically with the overall look of the route, contributing to the road's cohesive structure.

Manhole covers such as M.C.7, M.C.10, and M.C.13, which previously posed risks to pedestrian safety, were brought up to safety standards during the renewal process. These adjustments made the route safer for both pedestrians and drivers. Furthermore, removing the irregularities around these covers has created aesthetic harmony on the road surface, enhancing the urban appearance.

Misaligned covers, such as M.C.8, M.C.12, and M.C.14, as seen in Table 1, were realigned to improve driving comfort and ensure continuity on the road surface. Following the renewal, these covers contribute to the road's durability and aesthetic integration.

In summary, these comprehensive improvements have not only mitigated safety risks but also enhanced the overall appearance of the Kepez route. The results demonstrate how effectively applying renewal technologies can bring positive outcomes in urban areas.

RESULTS AND DISCUSSION

The renewal efforts for manhole covers along the Kepez route have yielded successful outcomes in terms of functionality and safety. However, to further enhance these initiatives and introduce innovative solutions, several recommendations can be proposed for future implementations.

Primarily, the adoption of smart manhole covers is recommended. These covers, equipped with sensors that monitor critical factors such as water levels and gas concentrations, can enable real-time hazard detection, thereby enhancing safety for both pedestrians and vehicles [29]. This technology offers the potential for rapid intervention against risks such as flooding during heavy rainfall or underground gas accumulations.

In addition, the durability of manhole covers can be improved through the use of advanced materials. Environmentally friendly and long-lasting materials can reduce the need for maintenance and repairs, promoting sustainability. Such materials would not only make the covers more resistant to wear and environmental impacts but also provide

a long-term solution. Improvements in material quality can further enhance the functional and aesthetic contributions of manhole covers.



Figure 2. Manhole cover design



Figure 3. Manhole cover design

Aesthetic and ecological designs could elevate the importance of manhole covers in terms of urban aesthetics and identity. In Japan, for example, manhole covers are designed as works of art, adorned with elements reflecting the city's cultural identity. This demonstrates how such designs can provide both functional and socio-aesthetic contributions [4].

These designs showcase manhole cover models that reflect Kepez's natural beauty and environmental awareness. In this context, enriching the manhole covers along the Çanakkale route with urban motifs could provide a unique contribution to the city's identity.



Figure 4. Manhole cover design



Figure 5. Manhole cover design

Similarly, manhole covers could be developed with guidance and navigational functionalities, integrating seamlessly into the urban fabric. For instance, incorporating city symbols into the designs of these covers could contribute to the promotion of urban culture and enhance visual cohesion [5].

These designs are examples of manhole covers featuring the Trojan Horse motif, reflecting Çanakkale's historical and cultural identity. Through such designs, they will serve not only as infrastructure elements but also as components that strengthen the city's identity.

In conclusion, the development of manhole covers on the Kepez route with innovative and aesthetically focused designs could serve as a model in urban transformation. Covers enriched with city symbols and motifs, designed with smart and environmentally friendly materials, could elevate Kepez in terms of both aesthetics and functionality. These recommendations, when applied to future projects, could provide modern infrastructure solutions that align with the city's identity and vision.

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