DESIGN AND CONSTRUCTION OF BUS STOP SHELTER USING COMPOSITE MATERIALS AND NEW BUILDING TECHNOLOGY

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ABSTRACT
Bus stops shelter is generally built by metal materials (iron) and glass. Metal will be corroded with the vicinity of moisture and outdoor spaces exposed to rain and snow. The glass of the shelter is fragile and reduces the safety of citizens within the station. Maintaining these materials needs high costs. Promotional stickers installed on rear glass have created dissatisfaction for citizens due to loss of vision for commercial and residential land uses in surrounding area. The installation of these shelters in narrow walkways will block the pedestrians’ walking path. Displacement of shelters needs high costs because it requires large cranes due to their excessive weight. For the installation of lighting equipment, metal body creates electrocution risks for citizens. Considering basic technical characteristics and requirements of the construction, inspection and maintenance of bus stop shelters in terms of destructive body and the corresponding foundation, the best materials were investigated based on safety of passengers on public transport, volume and weight of parts transported to location, maintenance costs, lighting and beauty. Finally, a bus stop shelter was designed and constructed using composite materials and new building technology. This kind of shelter was considered appropriate, especially for large cities such as Tehran having narrow walkways and their bus stop shelters are densely constructed on the sidelines of commercial uses, offices, etc.

Keywords: Bus Stop, Bus Shelter, New Building Technology, Composite

1. Introduction
Dense buildings, traffic on streets, the city landscape, parks, and urbane furniture give the city identity and comfort for the residents of the city and attractions for foreign tourists. For this reason, cities such as Venice, Los Angeles, Madrid and … are distinguished. Bus stop shelter in walkways of all the cities of the world is one of the most used facilities and urban furniture for citizens. Thus, they must have the visual beauty and the necessary strength. In addition, they must be fully compatible with the surrounding environment and have spaces for the installation of notifications related to the operation of public transport, including route maps and lines, and positioning and timing system, and the spaces have high readability for all citizens. One of the most important urban furniture for citizens is utilization of materials based on climatic conditions in various countries and cities that are reminiscent of the traditional beauty and attractiveness with combining technology and modern methods of construction to build a shelter for public transport. Destruction of shelter structures brings a lot of waste and trash for the environment, resulting in enormous costs of maintenance. For this purpose, traditional materials using modern technology are used for the construction of new shelters. Therefore, it is necessary to consider strategies
to improve the mechanical properties, such as the use of composite materials in its shelter. In this study, the effect of environmental conditions on the resistance of composite materials is investigated to understand their mechanical properties. The shelter must have properties including strength, toughness, durability, beauty, compatibility with the surrounding environment, and sufficient lighting system. In the open spaces, shelters should be resistant against the sun, rain and snow, and environmental conditions (frost and melting). Currently, shelter materials used in the construction of public transport in developing countries are very diverse and depend on environmental conditions.

2. Problems with the Current Status of Bus Stops Shelter

Now, the integrated metal structure of bus stop shelters is transported to the installation location by crane with a relatively high cost and then glass of the body is installed in a non-standard way. In the event of damage to the metal structure, it cannot be repaired easily and must be displaced by the crane. The glass of the shelter is fragile and reduces the safety of citizens within the station. The maintenance of these materials needs high costs. Promotional stickers installed on rear glass have created dissatisfaction for citizens due to loss of vision for commercial and residential land uses surrounding area. The installation of these shelters in narrow walkways will lead to blocking the path of pedestrians for crossing. Displacement of shelters needs high costs because it requires large cranes due to their excessive weight. For the installation of lighting equipment, metal body creates electrocution risks for citizens.

The lack of consistency, compatibility, and the beauty of the surrounding environment are considered as the main disadvantages of bus stop shelters. Destruction of shelter structures brings a lot of waste and trash for the environment, resulting in enormous costs of maintenance. (Figure 2-1)

![Figure 2-1 Problems with the Current Status of Bus Stops Shelter](image)

3 Formulation Bus Stop Shelter Design Methodology Based On the Technical Specifications [2]

3.1 General Technical Characteristics of Stations
3.1.1 Application
The guideline is used to determine common specifications of bus stop shelter, facilities and equipment needed for the construction, and placement of stations on the basis of characteristics of the station in the vicinity of walkways. [2]

3.1.2. Standards
In this guideline, the following criteria are important:

- CSA Standard, A23.3-04, Design of concrete structures, 2004
3.1.3. Terms and Definitions

- **Accessway:** [2], [23]
  A paved connection, preferably non-slip concrete or asphalt, that connects the bus stop waiting pad with the back face of the curb.

- **Adaptive use:** an individual's spontaneous, creative use of a facility or structure in ways that differ from or go beyond the intended use or the formal design.

- **Advertising shelter:** a bus shelter that is installed by an advertising agency for the purpose of obtaining a high-visibility location for advertisements. By agreement, the bus shelter conforms to the transit agency specifications but is maintained by the advertising company.

- **ADA:** American's with Disabilities Act of 1990. The Act supplants a patchwork of previous accessibility and barrier-free legislation with a comprehensive set of requirements and guidelines for providing reasonable access to and use of building, facilities, and transportation.

- **Amenities:** things that provide or increase comfort or convenience.

- **Bollards:**
  a concrete or metal post placed into the ground behind a bus shelter to protect the bus shelter from vehicular damage.

- **Bus Bay:**
  a specially constructed area off the normal roadway section for bus loading and unloading.

- **Bus Stop:**
  A bus stop is a designated place where buses stop for passengers to board or alight from a bus.

- **Bus Station Platform:**
  Bus station platforms may be assigned to fixed bus lines, or variable in combination with a dynamic passenger information system. The latter requires fewer platforms, but does not supply the passenger the comfort of knowing the platform well in advance and waiting there.

- **Bus Stop Spacing:**
  the distance between consecutive stops.

- **Bus Stop Zone Length:**
  the length of a roadway marked or signed as available for use by a bus loading or unloading passengers.

- **Bus Shelter:**
  a building or other structure constructed at a bus stop, to provide seating and protection from the weather for the convenience of waiting passengers.

- **Curb-side factors:**
  factors that are located off the roadway that affect patron comfort, convenience, and safety.

- **Curb-side stop:**
  a bus stop in the travel lane immediately adjacent to the curb.

- **Detector:**
  a device that measures the presence of vehicles on a roadway.

- **Discontinuous sidewalk:**
a sidewalk that is constructed to connect the bus stop with the nearest intersection. The sidewalk does not extend beyond the bus stop.

- **Headway:** the interval between the passing of the front ends of successive buses moving along the same lane in the same direction, usually expressed in minutes.
- **Roadway geometry:** the proportioning of the physical elements of a roadway, such as vertical and horizontal curves, lane widths, cross sections, and bus bays.
- **Sight distance:** the portion of the highway environment visible to the driver.
- **Street-side factors:** factors associated with the roadway that influence bus operations.
- **TCRP:** Transit Cooperative Research Program of the Transportation Research Board.
- **Upstream:** toward the source of traffic.
- **Waiting or accessory pad:** a paved area that is provided for bus patrons and may contain a bench or shelter.

### 3.1.4. Placement Considerations—Stop Spacing

The determination of bus stop spacing is primarily based on goals that are frequently subdivided by development type, such as residential area, commercial, and/or a central business district (CBD). [2], [23], [26]

Another generally accepted procedure is placing stops at major trip generators. The following are typical bus stop spacings used. The values represent a composite of prevailing practices. (Table 3-1) [23], [26]

#### 3.1.5. Requirements for the Zone Of Bus Stop

<table>
<thead>
<tr>
<th>Environment</th>
<th>Spacing Range</th>
<th>Typical Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Core Areas of CBDs</td>
<td>300 to 1000 feet</td>
<td>600 feet</td>
</tr>
<tr>
<td>Urban Areas</td>
<td>500 to 1200 feet</td>
<td>750 feet</td>
</tr>
<tr>
<td>Suburban Areas</td>
<td>600 to 2500 feet</td>
<td>1000 feet</td>
</tr>
<tr>
<td>Rural Areas</td>
<td>650 to 2640 feet</td>
<td>1250 feet</td>
</tr>
</tbody>
</table>

The following tips are essential for determining the zone of bus stop:

Dimensions for zone of station: the length must be determined according to station project on the street. The minimum length in roadside stations before and after the intersection is 27.5 and 30.5 m, respectively, and 46 m for roadside stations between two intersections. 6 meters should be added to the length of stations in which joint buses stop. In curb-side bus stops, the length of this zone consists of the five components: quarter of entry, reducing line of speed, zone of stops, increasing line of speed, and quarter of exit. Thus, the length of stop zone for normal buses and joint buses is 15 meters and 21 meters, respectively. Dimensions of other components should be determined based on Table 5-6. In open curb-side stations, there is no need to build a reducing line of speed. In far-side bus stops, there is no need to build a reducing line of speed and the quarter of entry but before the intersection, a specific line should be
constructed for turning right. If there is more than one bus in the station, 15 meters and 21 meters should be added to the length of the station zone for normal buses and joint buses, respectively. [2], [23]

• **Bus Stop Zone Design Types—Curb-Side Bus Stop Zone Dimensions**

The number of bus-loading positions required at a given location depends on 1) the rate of bus arrivals and 2) passenger service time at the stop. Table 3-2 presents suggested bus stop capacity requirements based on a range of bus flow rates and passenger service times. For example, if the service time at a stop is 30 seconds and there are 60 buses expected in the peak hour, two bus loading positions are needed. The arrival rate is based on a Poisson (random) arrival rate and a 5 percent chance the bus zone capacity will be exceeded. [2], [23]

<table>
<thead>
<tr>
<th>Peak-Hour Bus Flow</th>
<th>Capacity Required (Bays) When Service Time at Stop Is</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 Seconds</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>45</td>
<td>1</td>
</tr>
<tr>
<td>60</td>
<td>1</td>
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<tr>
<td>75</td>
<td>1</td>
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<td>90</td>
<td>1</td>
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<tr>
<td>105</td>
<td>1</td>
</tr>
<tr>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td>150</td>
<td>2</td>
</tr>
<tr>
<td>180</td>
<td>2</td>
</tr>
</tbody>
</table>

**Shelters—Inclusion and Sizing**

Standardized shelters exist that accommodate various site demands and different passenger volumes. Typically, a shelter is constructed of clear side-panels for clear visibility. Depending on demand and frequency of service, a bus shelter may also have a bench.

The decision to install a shelter is a result of systemwide policy among transit agencies. Many criteria exist to determine shelter installation at a bus stop. In most instances, the estimated number of passenger boardings has the greatest influence. Suggested boarding levels by area type used to decide when to install a shelter are as follows (these values represent a composite of prevailing practices): [2], [23]

**Location** | **Boarding**  
--- | ---
Rural | 10 boardings per day  
Suburban | 25 boardings per day  
Urban | 50 to 100 boardings per day

Other criteria used to evaluate the potential for inclusion of a shelter include:

• number of transfers at a stop
• availability of space to construct shelters and waiting areas
• number of elderly or physically challenged individuals in the area
• proximity to major activity centers
• frequency of service
• adjacent land use compatibility

Priority may or may not be given to each of these items depending on policy. System equity or funding availability can cause the installation decision to be made on a case-by-case basis. Local priorities and neighborhood requests can also influence the decision to include a shelter at a bus stop.
Other factors that can influence the size of the shelter include availability of right-of-way width, existing street furniture, utility pole locations, landscaping, existing structures, and maintaining proper circulation distances around existing site features.

**Requirements for Construction and Installation of Bench:**
For designing and installing the bench, the following cases should be considered: [21], [23]
- Available funds and priorities of regional and local demands
- Coordination with benches appearance and adjacent urban furniture
- The bench should be made of materials with non-slip surface, and are sturdy and resistant to atmospheric conditions and easy to clean.
- The possibility of sleeping for people is not provided on it.
- The accumulation of rainwater is not possible on it
- The width of the seat should be between 500 to 600 mm with a minimum length of 1100 mm. the minimum height of the backrest should be 460 mm and is installed with a maximum vertical distance of 50 mm from the surface of the seat. The bench should be installed at a height of 430 to 480 mm from the platform. It is recommended that the bench a hand with a height of 180 to 250 mm.
- The bench should have a 150 kg adequate structural resistance against vertical or horizontal pressure.
- A minimum distance of the bench from the back cub near the street should be 600 mm and the optimal distance is 1200 mm.
- The bench should not be installed within the scope of 1500 x 2400 mm for disabled people.
- The bench should not be installed in front of the place where passengers get on the bus.
- There should be a free space at least 900 mm for disabled people between the benches and other urban furniture.
- The bench should not be an obstacle for passengers to access the station.
- The bench should not be an obstacle for passengers to see signs and information map

**Amenities—Route or Patron Information**
Route and passenger information can be displayed in various ways. A flag sign is the most common method used by transit agencies to display information. Placement and design guidelines for flag signs. Installation of schedule holders or schedule and route information on the shelters are also commonly used.
The actual displays mounted on the sign can include the transit agency logo, route numbers available at the stop, type of route (local or express), and destination for a limited number of routes. Schedule holders are included at sites with large passenger volumes. The schedule holders can be mounted on the flag sign or inside a shelter. Information in Braille can be provided when a four-sided information holder is used.
Side panels may be large enough to display the entire system map and can include backlighting for display at night. Shelters that lack side panels can display route and schedule information on the interior roof of the shelter. [2], [23]

Some recommendations for route or patron information display are as follows:
- Provide updated information when changes are made to routes and schedules.
- Consider the quality and appearance of information displays. A visually poor route map conveys a negative impression of the system.
- Make information displays permanent. Temporary methods for displaying information (such as tape-mounting) create a cluttered, unsophisticated appearance at the bus stop.
- Follow ADA clearance, mobility, and visual guidelines for access of information by individuals with impairments. [23]
Installation Requirements for Notification Boxes:
The following points should be considered for the installation of the boxes:

- The height of each box should be 300 mm.
- The box should be installed about at a height of 700 to 2000 mm from the ground. The desirable height is 1200 to 1700 mm.
- In order to gain the trust of passengers, printing format and displaying information on the box should not be temporary.
- Information displayed on the box should be visible to people with disabilities on a wheelchair.
- The boxes must not have a danger to pedestrians.
- If changes occur on the bus route or schedule, this information should be updated as soon as possible. [2], [23]

Illumination:
Minimum illumination of the bus stop space must be 20 to 55 lx to provide a sense of security and ease of viewing the information on the notice boards for passengers in the dark hours a day. Technical specifications of electrical installations and lighting system inside the shelter must comply with the minimum specifications given in the guideline.

Amenities—Lighting
Lighting affects bus patrons’ perception of safety and security at a bus stop, as well as the use of the site by non-bus patrons. Good lighting can enhance a waiting passenger's sense of comfort and security; poor lighting may encourage unintended use of the facility by non-bus patrons, especially after hours. Lighting is particularly important in northern climates where patrons may arrive and return to the stop in darkness during the winter season. Illumination requirements are often a policy of individual transit agencies; however, installing lighting that provides between 2 to 5 footcandles is the general recommendation. Cost and availability of power influence the decision to install direct lighting at a bus stop. Direct lighting is expensive and difficult to achieve at remote locations. When installing direct lighting at a bus stop, the fixtures should be vandalproof but easily maintained. For example, avoid using exposed bulbs or elements that can be easily tampered with or destroyed.

A cost-effective approach to providing indirect lighting at a site is to locate bus stops near existing street lights. When coordinating bus shelter or bench locations with existing street lights, the minimum clearance guidelines for the wheelchairs should be followed. Figure 3-1 is an example of coordinating a shelter with an existing street light. [2], [23], [26]

Figure 3-1. Example of Coordinating Shelter Locations with an Existing Street Light.

Amenities—Trash Receptacles
Trash receptacles can improve the appearance of a bus stop by providing a place to dispose of trash. [23], [26]
The installation of trash receptacles is typically a systemwide decision and the size, shape, and color reflect transit agency policy. Not all bus stops have trash receptacles. Low patron volumes may not justify the inclusion of this amenity at a bus stop; however, litter at a site may warrant the inclusion of a trash receptacle at an otherwise low-volume location. Problems can arise when the receptacles are not regularly maintained or when the bus stop is next to a land use that generates considerable trash such as convenience stores and fast food restaurants. In such cases, transit agencies should work with these establishments to define maintenance responsibilities for the bus stop and the area around the businesses. Businesses and community groups typically are reluctant to agree to maintaining trash receptacles at public sites. [23], [26]

**Recommendations regarding installing a trash receptacle at a bus stop are as follows:**
- Anchor the receptacle securely to the ground to reduce unauthorized movement.
- Locate the receptacle away from wheelchair landing pad areas and allow for at least a 3-foot separation from other street furniture.
- Locate the receptacle at least 2 feet from the back of the curb.
- Ensure that the receptacle, when adjacent to the roadway, does not visually obstruct nearby driveways or land uses.
- Avoid installing receptacles that have ledges or other design features that permit liquids to pool or remain near the receptacle—this may attract insects.
- Avoid locating the receptacle in direct sunlight. The heat may encourage foul odors to develop.

Figure 3-2 shows the minimum circulation and separation requirements for trash receptacles at bus stops. [23], [25], [26]

![Figure 3-2](image_url)

**Roadmap:**
A map of the station location is provided in a part of the wall of the shelter in order to give the necessary information related to the continuation of the bus routes for passengers. These maps should cover the following information:
- Information on public transport lines and stations and the main passages as well as displaying the station location by means of labels "You Are Here"
- Close-up view of an area of the station and adjacent areas.
- Table of all lines of the station with bus arrival time tables for both working days and holidays.

**3.2 Technical Specifications for Shelter Construction**

**3.2.1 Application:**
The guideline is used to determine the minimum requirements for construction of shelter and technical specifications of materials. [2], [23]
3-2-2- Construction of a shelter:
A bus stop shelter, with any building design, should possess the following characteristics:

- Protection: a shelter must protect the passengers against bad weather, during the waiting time.
- Notification: The shelter should provide necessary information about the location of previous and next stations.
- Comfort: There must be a bench or adequate facilities for all passengers, passengers with disabilities and those who carry a cart.
- Security: Passengers waiting at the shelter should feel safe.
- Shelter construction according to the weather: Considering weather conditions of shelter location (especially during peak hours) is necessary in the construction of the shelter.

Shelter should be built to allow air circulation inside it and prevent overheating of the space in the warm months.

3.2.3 Shelter Construction Requirements:
The follow points should be considered for the design of a shelter: [21], [23]

- The width of the shelter should be between 1.2 to 1.5 m and its length should be between 2 to 5 m.
- A minimum width for entrance to the shelter should be 800 mm.
- There should be a free space at least 900 to 1200 mm inside the shelter scope for people with wheelchairs, carts and strollers during the waiting period.
- The minimum height of the underside of the canopy should be 2200 mm.
- Bench with capacity of at least 4 people under the canopy is desirable.
- There should be a space for displaying the station name in a visible manner to the public.
- There should be a space for installation of location map in the shelter.
- Advertising and publicity installed in the shelter should create a barrier to the view of passing traffic.
- There should be an unhindered scope inside the shelter in order that passengers can access the information.
- Shelter must contain information as to the name and contact number of the responsible unit in case of emergency.
- In add-on equipment, such as public telephones, information boards, etc., there must be a balance between the security, the cost, and the passengers’ sense of comfort.

3-2-4- requirements of the materials used in the construction of the shelter:
The raw material must be chosen so that there is a balance between beauty and performance. For the choice of materials used in the construction of the shelter, the following points should be considered: [14]

- Shelter components should not have a sharp surface.
- The best materials are those that are weatherresistant, can withstand continual use, and can be easily maintained. The ease with which a particular material can be vandalized can reduce its desirability; easy-to-clean materials are desirable.

3-2-5- materials used in the shelter:
Primarily, metal, concrete, brick, glass, and plastics are used at bus stops. [2], [23]

A summary of the advantages and disadvantages of materials is presented in Table 3-3.
- Brick: in the traditional buildings, columns, flooring, seats can be used.
- Metals: Metals are considered as main materials in the construction of shelter skeleton, benches, bridges, and trash cans. The use of metal is not recommended for construction of seat and backrest. The detailed specifications of profiles, plates, and bars are provided in the maps of the appendix. Thickness for electrostatic paint of metal parts and other materials in shelters must be 120 micron. The use of aluminum is recommended for areas where the probability of theft is minimal.
Concrete: the best use of concrete in a shelter is construction of infrastructure and platform. The minimum compressive strength of concrete used in the construction of the foundation and platform must be $f'c_{25}=25\text{MPa}$. In other structural elements such as columns and ceiling, it should be $f'c_{28}=28\text{MPa}$.

Composite materials: Composite material is a material made from two or more constituent materials with significantly different physical or chemical properties.[11],[12]

An important advantage of these materials:
1. Lightweight
2. Flatness and color uniformity
3. Formability
4. A variety of colors
5. Fire resistance
6. Unconsolidated performance in earthquake
7. Possibility of sealing
8. No need to rinse
9. Interchangeable panels
10. Acoustic properties

Glass: the type of glass used in the side wall of the shelter must be tempered glass and at least 10 mm thick.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick</td>
<td>• It can easily be replaced or repaired.</td>
</tr>
<tr>
<td></td>
<td>• It has a very beautiful view.</td>
</tr>
<tr>
<td>Metals</td>
<td>• Tensile strength and high pressures</td>
</tr>
<tr>
<td></td>
<td>• They are used for construction of a large number of elements in shelters.</td>
</tr>
<tr>
<td>Concrete</td>
<td>• It is used as a foundation to enhance structural strength.</td>
</tr>
<tr>
<td>Composite materials</td>
<td>• Lightweight.</td>
</tr>
<tr>
<td></td>
<td>• High resistance.</td>
</tr>
<tr>
<td></td>
<td>• Formability</td>
</tr>
<tr>
<td>Glass</td>
<td>• Ease of cleaning</td>
</tr>
<tr>
<td></td>
<td>• High transparency</td>
</tr>
</tbody>
</table>

3.3 Technical specifications for installation, inspection, and maintenance of the shelter in stations

3.3-1- Application:
The guideline is used to determine installation requirements and methods of inspection and maintenance of shelters. [24], [25], [26]

3.3-2- shelter placement:
Placement of shelter should be considered according to environmental specifications, existing privacy of passage, the width of sidewalks and buildings. [24], [25], [26]

Figure 3-3 from the Bus Stop Design Guide shows a bus stop prototype. Other examples are included in the discussion in chapter three. [24], [25],[26]

**SHELTERS—Configurations and Orientations**

In orienting and configuring bus shelters, personnel should consider the environmental characteristics of each site, because placement and design can positively or negatively influence passenger comfort.

Shelters can be completely open to permit unlimited movement of air, or panels can be erected to keep the interior of the bus shelter warm. Alternatively, shelters can be fully enclosed by solid panels and the back of the shelter may be rotated to face the street to protect waiting passengers from splashing water or snow build-up. [23]

bus shelters may be uncomfortable if they face directly east or west.
Figure 3-4 Placement and Orientation Options. [23]

3-3-3- shelter installation requirements:
For the installation of shelter, the following factors should be considered:
The establishment of the shelter must be in a way that the waiting passengers do not occupy the spaces in the sidewalk. The absolute minimum width for pedestrian traffic in front or behind the shelter must be 900 mm and the desired value is 1500 mm.
Note: the aforementioned values are minimal. In any case, the values must be based on theoretical capacity and service level.

- The minimum distance to the bus for freedom of movement and avoiding collisions with other objects beside the mirror must be 600 mm from the edge of the curb until the end of the eaves of the shelter.
- Shelter should be installed within the vicinity of the bus stop scope as much as possible.
- The establishment of shelter is not recommended in front of the windows of business buildings.
- Shelter walls should be installed at a height of 150 mm from the waiting platform floor or sidewalk.
• Shelter must not be installed in front of outputs of congested buildings or pedestrian bridges. For the installation of the shelter, a special attention should be given to the collection of surface water, and water spray by the moving vehicles to passengers. [23],[26]

![Shelter Clearance Guidelines]

**Safety requirements:**
Considering the following safety precautions is required when installing a shelter:
The contractor shall take the necessary measures for the safety of human resources and pedestrians based on technical and administrative provisions of the Tehran Municipality. Supervision system is required to consider safety and traffic control during the installation procedure. In any case, the contractor is responsible for directing traffic.

Shelter maintenance: proper maintenance and quick repair of damaged urban furniture, such as shelters, create a good image in the minds of citizens to public vehicles and encourage them to use these facilities. [2],[23]

**Maintenance operations:**
Maintenance operations include the following cases: [2],[23]

- Washing and Cleaning the shelter and all equipment and accessories to a distance of 3 meters of the station
- Pruning tree branches and leaves as an obstacle
- Color correction of damaged and tarnished components
- Investigating shelter lighting and replacement of defective lamps
- Controlling panel protection status and cabling, and replacement of defective installations
- Investigation and control of electricity and grounding system
- Repair and refurbishment of all defective equipment

**Maintenance requirements:**
Shelter must be regularly inspected at least four times a year. Repair and restoration of components that have safety problems should be promptly done (within 24 hours) after obtaining information. Repair and restoration of components that do not have safety problems should be done during one week. [23]

3.4 Design stage of project and maps for the new bus stop shelter
3-4-1 early design stages to achieve the desired option:
In this study, many options were evaluated in order that the project is based on all the expected indicators and Iranian-Islamic architecture, and has no defects of the existing shelters and there is economic justification for initial operational costs during the construction and maintenance. With an emphasis on the use of available materials, the use of metal (iron) for core shelter skeleton with reinforced concrete foundations increase the tensile strengths and coverage around pillars and floors of the building materials.
and brick, and create traditional beauty, and extend the life of metal cores. Composite roofing with solar panels to produce energy for lighting, and monitoring the notification system for public transport, and passing of the cables through pipes embedded in the core of the roof provide safety for passengers. Thus, Characteristics expected from shelters are improved, and they reduce environmental pollution and promote community safety.

3-4-2- Details of the final design for bus stop shelters in 3D MAX and AutoCAD software:
After receiving the comments of specialists, experts, urban management, practitioners and stakeholders, all options related to mapping and simulation of the project were applied by 3D MAX and AutoCAD software. At this stage, changes occurred in details of the project and then it was finalized. Shelter design simulation was done by 3D MAX software (Figures 3-6 to 3-8).

![Simulation of Bus Stop Shelter by 3D MAX Software](image)

Figures 3-6 Simulation of Bus Stop Shelter by 3D MAX Software

![Simulation of Shelter of station with pot by 3D MAX Software](image)

Figures 3-7 Simulation of Shelter of station with pot by 3D MAX Software
Figures 3-8  Simulation of Shelter Lighting by 3D MAX Software

Figures 3-9  Details of bus stop shelter project in AutoCAD software
Figures 3-10 Side view from the left of the design of bus stop shelter

Figures 3-11 Front view from the left of the design of bus stop shelter

Figures 3-12 Side view from the right of the design of bus stop shelter
Figures 3-13 Implemented projects of the design of bus stop shelter

4. Discussion and Conclusion
In this study, the weaknesses, problems, and shortcomings of the existing bus stop shelters were considered: The integrity of the body and the metal structure of shelters prone to rusting and damage make the structure heavy and difficult to carry. Therefore, it will cause high transportation costs by crane, the possibility of failure, and structural deformation. In addition, the metal body repair is not an easy task. The other defects of the existing bus stop shelters are as follows: it is not possible to install the shelter in the narrow sidewalks; for the installation of lighting equipment, metal body creates electrocution risks for citizens; the glass of the shelter is fragile and reduces the safety of citizens within the station; the maintenance of these materials needs high costs; lack of beauty and incompatibility with the surrounding environment have caused urban furniture to be challenged by citizens. Given that the purpose of the research is design and construction of bus shelters with regard to all facilities and environmental standards, energy savings, strength, durability, lighting, information technology, reliability and beauty, and reducing maintenance costs with the use of composite materials and new technology, each purpose was improved as follows:

The main advantages of the new design of the bus stop shelter compared to the existing bus stop shelters:
- Ease of construction of various parts using modern technology, alternative materials and lighting, especially in pre-fabricated roof and main components (pillars and ceilings).
- Ease of the use of modern technology in bus fleet management and exploitation of intelligent systems in the body wall (pre-positioning polyethylene pipes in columns and ceilings).
- Possibility of passing electrical installations and pipelines, and hiding cables for travel-time monitoring
- Ease of installing other equipment with new technologies and services for the citizens
- 90% savings in energy consumption using solar panels to reduce maintenance costs because of hiding lighting installations (cable, solar panel, etc.) in the body and ceiling of shelters.
- Environmentally friendly
- Durability and reliability at a rate of 80% because of declining the need for maintenance (rusting metal skeleton and breaking glass of the shelter).
- Beauty of form and materials of the front facade using anti-pollution solutions

Hence, it can be concluded that the construction of a bus stop shelter according to this design will have the better performance in terms of cost and other evaluation criteria.

5. References
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