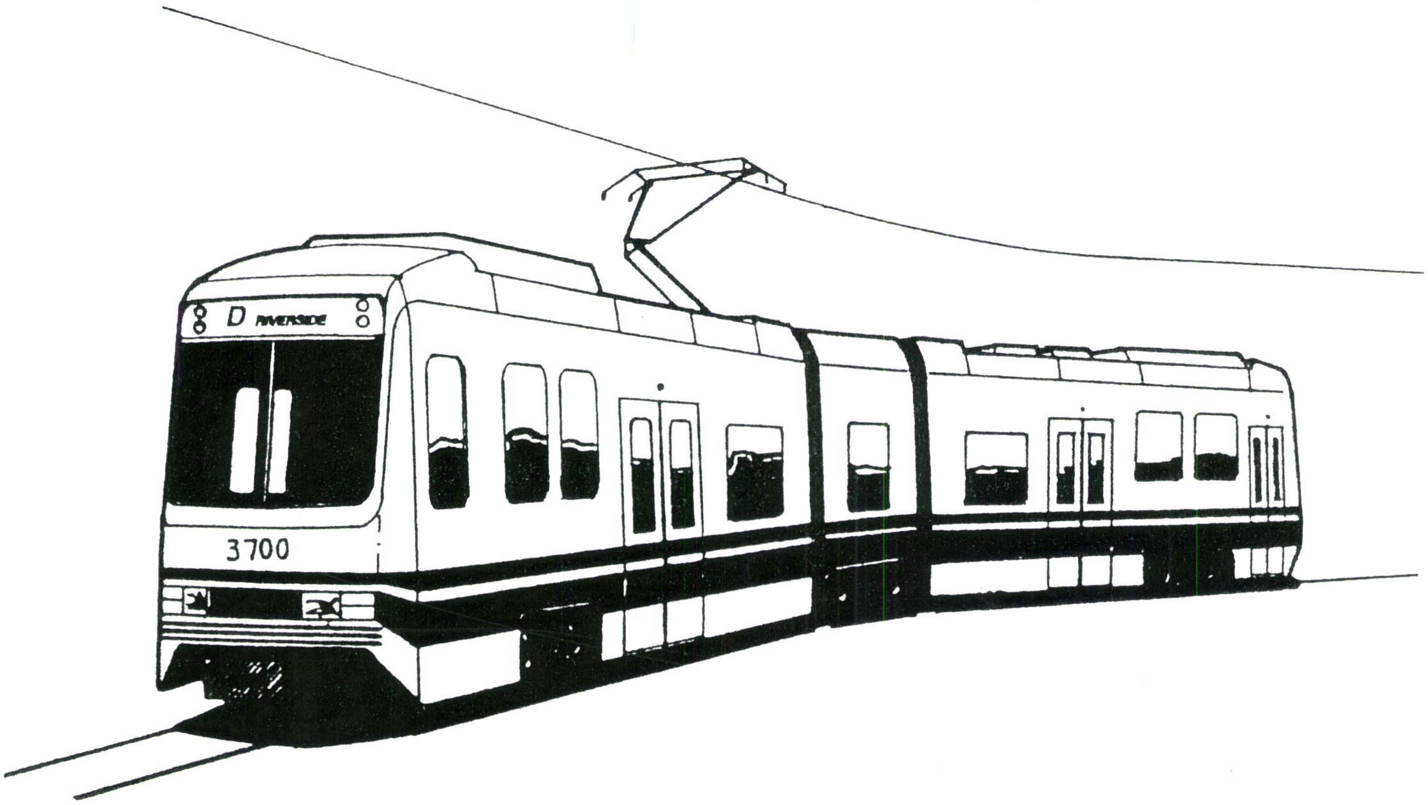
Massachusetts Bay Transportation Authority
MBTA Contract No. S5PS11

Light Rail Accessibility Program
Green Line
Project Design Manual



Gannett Fleming
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1.0 Introduction

The Light Rail Accessibility Program (LRAP) is being implemented by the Massachusetts Bay Transportation Authority (MBTA) to create a Light Rail Transit system which will be accessible to all who wish to use it. The MBTA is committed to making the entire transit system accessible in accordance with the requirements of the *Americans with Disabilities Act* (ADA) and the *Massachusetts Architectural Access Board* (AAB).

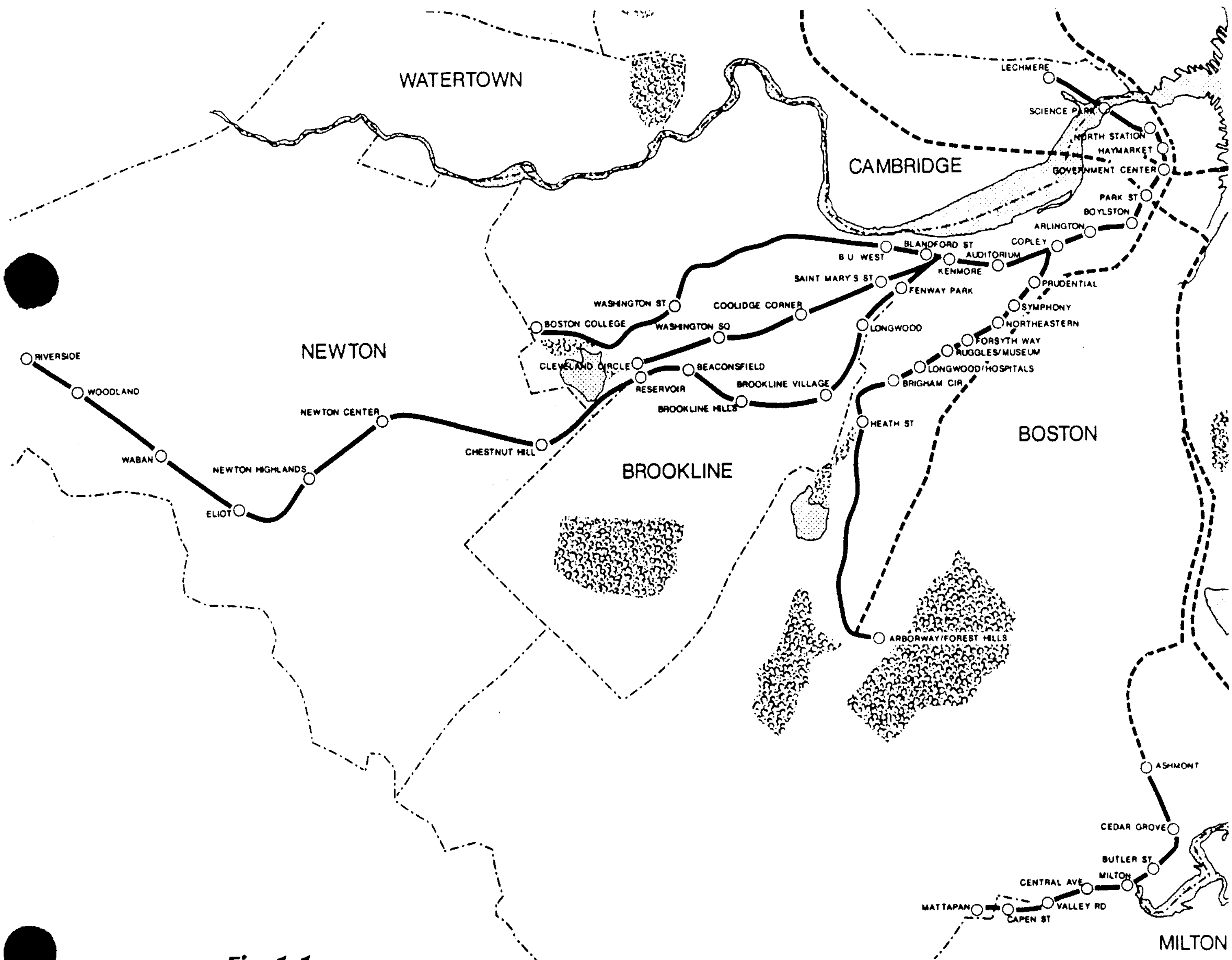


Fig. 1-1
MBTA System Map - Light Rail Accessibility Program

1.0 Introduction

The Authority's Light Rail System consists of 70 station/stops along the system's Green Line and 8 station/stops on the Mattapan to Ashmont branch of the Red line. The Green Line presently operates two types of light rail vehicles (Boeing LRV's and Type 7's). The Mattapan Line is served by the older PCC trolleys. The Light Rail System operates on a variety of configurations; the central subway, median reservations, dedicated rights of way, and shared rights of way.

Although the MBTA intends to provide accessibility throughout its entire transit system, the size and complexities of the Light Rail System warrants a separate analysis and development of standardized solutions.

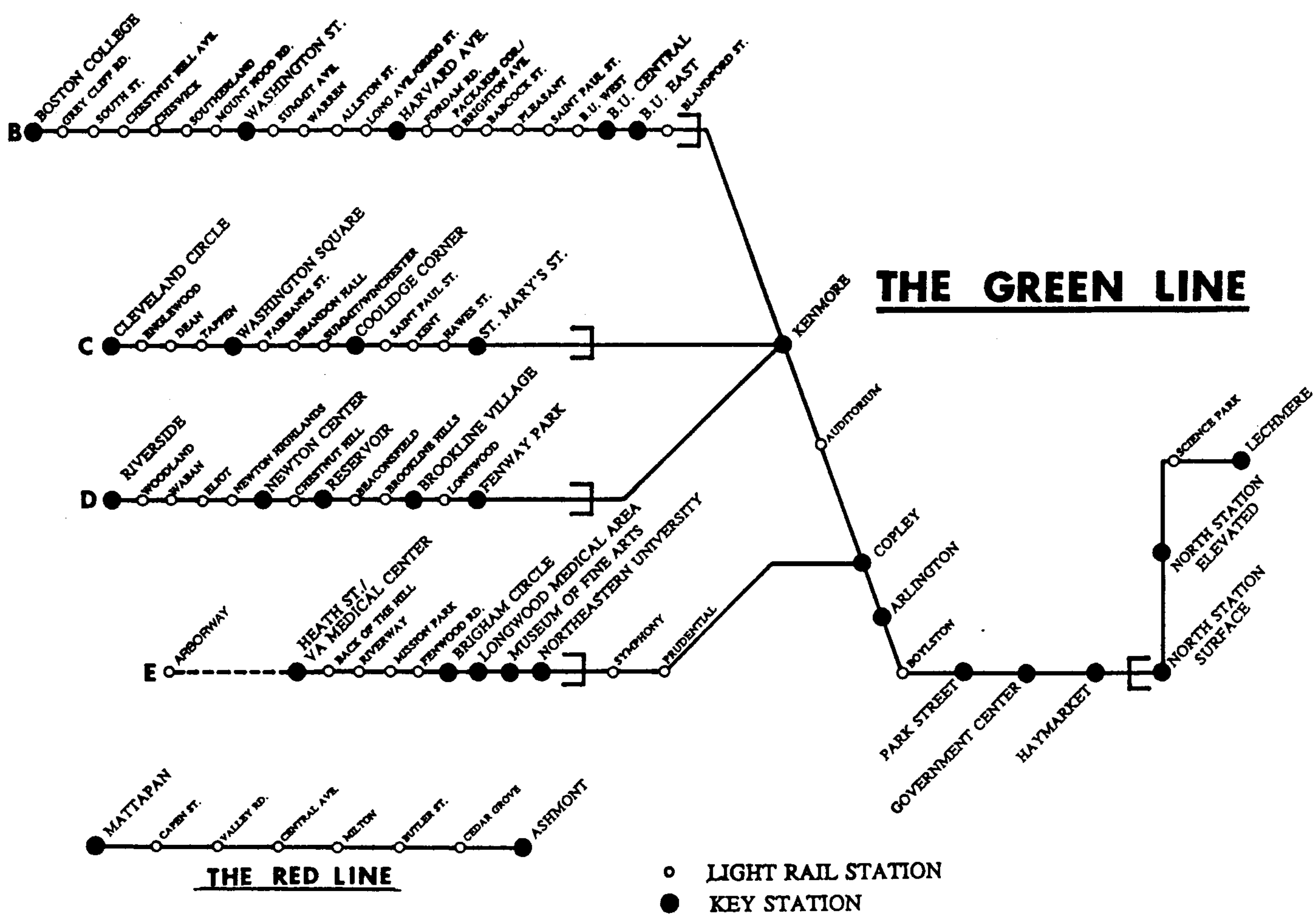


Fig. 1-2
MBTA Key Station Plan

To facilitate system-wide accessibility compliance, the ADA regulations make provision for a key station plan which has allowed the MBTA to designate only certain stations for accessibility compliance for people who use wheelchairs. Out of a total of 78 light rail stations/stops, 29 are designated as key stations. Furthermore, the Key Station Plan also establishes a compliance schedule for the 29 key stations which spans 10 years.

In the late 1980's the MBTA prepared a feasibility study which identified and evaluated various approaches to providing an accessible Light Rail System. Based on the study's conclusion the MBTA selected an approach which involves the purchase of new low floor vehicles (LFV's) to supplement and eventually replace the existing LRV fleet. Corresponding station modifications will include raised platforms, ramps, elevators and other access improvements.

1.1 Project Objectives

Although the immediate and most important objective of LRAP is to provide an ADA and AAB compliant Light Rail System, the overall project goals are in actuality much broader. The magnitude of the project has presented the Authority with an opportunity to establish a significant number of goals, some of which are as follows:

- Provide an ADA and AAB compliant Light Rail System.
- Through access related modifications, improve the safety, security, comfort and convenience to system patrons.
- Work towards improving station environments and identities in relation to surrounding neighborhoods.
- Where practical, make provisions for future ridership growth.
- Make the necessary systemwide modifications to accommodate the future low floor vehicles.

Given the large number of Light Rail Key Stations and the fact that the accessibility program is planned to be implemented over a ten year period, a significant number of architects and engineers will be involved in the design of the various stations. This *Project Design Manual* (PDM) will assist in establishing design objectives and guidelines to these various designers so as to ensure that the MBTA's general requirements are met.

The *Project Design Manual* will help to fulfill the following objectives:

- To establish the minimum requirements needed to bring a station into compliance with applicable accessibility regulations.
- To establish general design criteria.
- To ensure that station designs properly interface withoverall systemwide elements and transit operations.
- To identify and reinforce existing applicable MBTA design criteria and standards and compile them into a single document.

For the purposes of the Authority's LRAP, a *Schematic Design Report* (SDR) has also been prepared which presents Key Station design at 15% completion. The *Project Design Manual* is a companion to the SDR; however, the PDM is intended to be able to stand alone and serve as a design guide for all of the MBTA's Light Rail System Accessibility Projects.

The servicing and inspection requirements of the new low floor cars are important components of this project. The introduction of the low floor vehicle fleet will require alterations to the MBTA's three existing Maintenance and Inspection Facilities. An analysis of these requirements is presented in a separate document.

1.2 Purpose and Use of the Manual

The purpose of this Manual is to provide guidance to the Authority and its design consultants in current and future Green Line accessibility design. Given the diversity of conditions found in the system, it would be neither prudent nor, in many instances, necessary to "standardize" all elements of the Light Rail system. The approach of this Manual is to recommend standardization of components only when it is economically justified, when it is required for legal or technical reasons, or when it adds a desired consistent design image.

The objectives of this Manual are to establish the accessibility requirements for:

1. Key Station Elements,
2. Program Access,
3. "Other" Access.

This Manual establishes three levels of guidance in the design of system improvements: design objectives, design guidelines, and system-wide elements

1. Design objectives are the most general form of guidance, broadly outlining the desired result of a component of the facility.

2. Design guidelines are a more specific form of guidance. They describe the level of performance a facility should achieve: location, types of user, standard dimensions, clearances, and where appropriate, several approaches to meeting the guidelines.

3. System-wide elements are also addressed as attempts to standardize pieces of the system. These detailed elements may describe specific construction methods or materials which the Authority requires the designer to use in specific circumstances. An example is pedestrian track crossings. It is not the intent of this document to force design ideas on consultants but rather to show examples of such ideas and their usefulness. Station designers must consult with the Authority prior to standardizing any element.

The technical sections of this report provide detailed coverage only of issues specific to low floor cars and related requirements for compatible fixed facilities needed to meet access goals and standards. Thus this Manual must be used in conjunction with other Authority and industry standards, and appropriate codes and regulations for development of contract documents. It is essential to the success of the program that all the individual disciplines review the entire Manual so that they understand how the pieces fit together in a harmonious manner.

1.3 Organization of the Manual

The Manual is organized into three major sections:

1. Station Elements
2. Light Rail Facilities and Systems
3. Engineering

The Manual is presented in a loose-leaf format for reasons of flexibility and convenience. It will be updated as needed.

1.4 Station Accessibility Requirements and Regulations

The Americans with Disabilities Act (ADA) requires public transportation systems not to discriminate against people with disabililties. The Act includes requirements for key stations to be made accessible. By July 26, 1995, all Light Rail and Rapid Rail lines must have one car per train accessible to persons who use wheelchairs. This Manual presents pertinent technical and scoping guidelines as established in:

- *ADA Accessibility Guidelines* (ADAAG) - 36 CFR Part 1191

- *ADAAG for Transportation Vehicles* - 36 CFR Part 1192

- *Transportation for Individuals with Disabilities,* Department of Transportation - 49 CFR Parts 27, 37, 38

- *Nondiscrimination on the Basis of Disability in State and Local Goverment Services,* Department of Justice - 28 CFR Part 35.

For the existing MBTA System, the obligations under ADA are in three categories:

1. Key Station Elements
2. Program Access
3. Alterations

The *MBTA Guide to Access* also provides guidelines and standards for accessible station design. The *Guide to Access* must be used for all station designs.

When conflicting issues occur, the MBTA Design and Construction Department will provide guidance.

The following is a discussion of the requirements under ADAAG, AAB and the *MBTA Guide to Access.*

1.5 ADAAG Key Station Requirements

Accessible Route

Accessible Route
ADAAG

- Under ADAAG, at least one accessible route from an accessible entrance must be provided to those areas necessary for use of the transportation system. While Key Station requirements are not clear concerning the accessible route to the station entrance(s) (See ADAAG 10.3.2), program access requirements do include an accessible route.
- The circulation path for persons with disabilities shall coincide with the circulation path for the general public to the maximum extent practicable.
- All features of the accessible path of travel shall be accessible. This includes walkways, ramps, elevators, bridges, doors, corridors, and fare gates.

Entrance

Entrance
ADAAG

- ADAAG calls for one accessible entrance. The determination of what is an entrance has an impact on compliance for path of travel and signage. What constitutes a "station entrance" varies from station to station. The MBTA should be contacted on this issue where existing stations have more than one entrance since neither ADAAG nor AAB clearly define "entrance". The following is a clarification of how "entrances" are to be considered for purposes of complying with Key Station Requirements.

1. For subway stations, the entrance will be the elevator headhouse or station headhouse leading to the elevator.

2. Entrances to surface stations within median strips are at the adjacent crosswalks, where the median strip meets the crosswalk.

3. Entrances to off-street surface stations are more complex to define. The basic consideration shall be an analysis of pedestrian traffic from a public way into the station.

4. The entrance to a grade separated surface station is the entrance to the ramp. This occurs where the entrance and platform are at two different levels.

Signage

Signage
ADAAG

- Where the accessible path does not coincide with the general path, signage shall indicate the accessible path. (See ADAAG 10.3.1.)
- Where station signs are provided at entrances, tactile signage shall be provided as well.
- Where station signage exists but there is no defined entrance, tactile signage shall be placed in a central location.
- Station signs, maps, and graphics shall comply with finish, contrast, character height, and proportion.
- Station identification signage also shall be provided at compliant heights for viewing from train cars whether sitting or standing to a maximum extent practical.
- At least one tactile station identification sign shall be located on each platform.

Fare Collection

Fare Collection
ADAAG

- Automatic fare vending machines shall be accessible.

Tactile Surfaces

Tactile Surfaces
ADAAG

- Platform edges bordering a drop-off to the tracks shall have a 2 foot wide detectable warning strip along the drop-off.

Train Boarding and Platforms

Train Boarding and Platforms
ADAAG

- Provide an accessible path of travel between the station platform and an accessible entrance to the Light Rail vehicles which stop at the station.
- ADA requires one accessible vehicle per train and one accessible entrance per vehicle. However, due to operational constraints, the MBTA may prefer that each vehicle entrance, equipped with a deployable ramp, be available to a person in a wheelchair. (Currently 4 per vehicle, 2 on each side.)
- If specific stop locations are designated, accessible directional signage must be provided.

Car Entrance

Car Entrance
ADAAG

- The gap between platform and car floor is required to be within certain limits depending on whether it is at a new or existing station. (See ADAAG 10.3.1 and 10.3.2.) The vertical gap permitted varies from 5/8″ to 1-1/2″. The horizontal gap is limited to 3″. If these gaps are larger than ±1 1/2" vertically or 3" horizontally, the gap must be spanned with a bridge plate.

Lighting

Lighting
ADAAG

- Uniform illumination levels are required along circulation routes. Uniform and non-glare illumination is required at signage.

Public Telephones

Public Telephone
ADAAG

- A text telephone is required where telephones are provided in the interior of stations.

Track Crossing

Track Crossing
ADAAG

- At track crossings, the surface shall be level, flush with the rail, with maximum flange gap of 2 1/2″.

Communications
ADAAG

Communications

- Where a public address system is provided, a visual system shall also be provided (e.g. an electronic sign system).
- Where a clock is provided, it shall be clearly visible, with high contrast and compliant numerals.

Elevators
ADAAG

Elevators

- Elevators shall comply with guidelines and codes, including controls, glazing and interior floor space.

1.6 Program Access Elements

Beyond Key Station requirements, ADA obligates a public transportation system, when viewed in its entirety, to be readily accessible to and usable by individuals with disabilities. Two features are specifically related to stations under program access: parking and drop-off/pick-up areas. Consideration shall be given to the means for a person using a wheelchair to gain access to the station from parking, a drop-off/pick-up point, or a public sidewalk.

1.7 AAB Requirements

In addition to the Key Station Requirements summarized above, each station needs to comply with some or all of the following AAB requirements. Specifically:

1. AAB requires that all items affected by the renovation project be made compliant.
2. If the cost of the work is more thant $50,000, but less than 25% of the current value of the facility ($100,000 and 30% with a $500,00 exemption for transit facilities in the Draft AAB Regulations), then an accessible entrance and toilet room shall be provided.
3. If the cost of the project exceeds 25% of the current value of the facility (30% in the Draft AAB Regulations) then the entire facility must be made fully accessible in accordance with AAB regulations.

If the project triggers the full compliance requirement, the following criteria must be met.

Entrances

Entrances
AAB

- AAB regulations require that the primary public entrance be accessible. These regulations are currently under review and any changes will be presented in an updated *MBTA Guide to Access*.

- Overhead protection or snow melting provisions are required in the immediate exterior area of station entrances into structures.

Doors

Doors
AAB

- Where doors are provided, they shall comply with AAB regulations as to width, clear and level floor area, closing speed, pressure, thresholds, and hardware height and type.

Stairs

Stairs
AAB

- Where stairs are provided as part of a means of egress, AAB requires that they shall comply regarding nosings, risers, treads and handrails.

Seating

Seating
AAB

- According to the current AAB requirements seating must be provided at intervals no greater than 250′ along all paths of travel between the station entrances and all platforms or boarding areas. The Draft AAB Regulations require seating at intervals of 200′.

Shelters and Canopies

Shelters and Canopies
AAB

- The current AAB does not require that canopies be provided over platforms or mini-high platforms at Light Rail stations. However, where provided, platform canopies and shelters must be located along an accessible path of travel and have sufficient interior space for a person in a wheelchair to enter, turn, wait and exit.

Toilet Rooms

Toilet Rooms
AAB

- If station toilet rooms are available for public use, they must be accessible. This includes signage, doors, floor space and fixture dimensions.

Public Telephones

Public Telephones
AAB

- Wherever telephones are provided, exterior or interior, AAB requires a telephone that is wheelchair accessible, hearing aid compatible, and with volume control.
- The Draft AAB requires an outlet and shelf with 6" high clearance at a bank of three or more public telephones.

Fire Alarms

Fire Alarms
AAB

- Where provided, fire alarms shall have visible and audible signals.

1.8 Additional *MBTA Guide to Access* Requirements

Accessible Route

Accessible Route
MBTA

- All pathways are required to be well lit.

Doors

Doors
MBTA

- Glass doors shall be distinguishable from adjacent windows.

Ramps

Ramps
MBTA

- Slopes of 1:12.5 or less are required, except at curb ramps which are 1:12.

Fare Collection

Fare Collection
MBTA

- An electronic speak-thru is required at all fare booths.

Tactile Surface

Tactile Surface
MBTA

- Platform edges which are level with the track bed within boarding areas at mid-track crossings shall have a 2 foot wide detectable warning strip.

Seating

- A 36" wide wheelchair space is required next to all benches.

Seating
MBTA

Public Telephones

- Telephones shall be placed in quiet areas.

Public Telephones
MBTA

1.9 Codes and Guidelines

In the preparation of final design documents for the Light Rail Accessibility Program the following documents should be referenced generally for their applicable technical subject. Please note that this list may not be all inclusive.

- ADA Accessibility Guidelines
- American Association of State Highway and Transportation Officials Standards
- American Railway Engineering Association (AREA) Standards
- LRAP Project Design Manual
- LRAP Schematic Design Report
- Massachusetts Architectural Access Board Regulations (current and Draft)
- Massachusetts State Building Code (5th Edition)
- Massachusetts State Elevator Regulations (1989)
- MBTA Guide to Access (Rev. 1995)
- MBTA Standard Specifications
- MBTA Manual of Guidelines and Standards (Rev. 1990)
- National Fire Protection Association Life Safety Code Handbook and NFPA 130
- National Register of Historic Places Regulations
- All Applicable Federal, State and Local Regulations & Statutes

If it becomes impossible, impractical or not feasible to meet the requirements of the above referenced documents, the Designer may propose alternatives to the MBTA and other governing bodies for approval on a case-by-case basis.

2.1 Design Objectives

The existing light rail system travels, both below grade and on the surface, through an array of urban neighborhoods with highly varied uses, characters and densities. This section of the *Project Design Manual* presents design guidance for the station components that will be affected by the accessibility program, many of which will have a substantial visual impact on the surrounding urban fabric.

The criteria that follow concerning station elements reflect new vehicle requirements, applicable codes, and the current MBTA guidelines. Close reference to those requirements as well as to this Manual and its *Schematic Design Report* companion, will be required throughout the final design stages of this project. The *Project Design Manual* is also meant to provide guidance for light rail stations that are not included in this project, but may be made accessible in the future.

The overall design goals developed in order to direct later design phases are:

- Provide an easily accessible system that is also a positive addition to the existing environment through careful attention to the functional requirements as well as the visual quality of each of its elements.
- Reinforce the local identity of the neighborhoods by allowing plazas, entrances, headhouses, and access paths to relate to the surrounding context.
- Maintain the linear identity of the rail system through consistent application of certain system-wide elements.

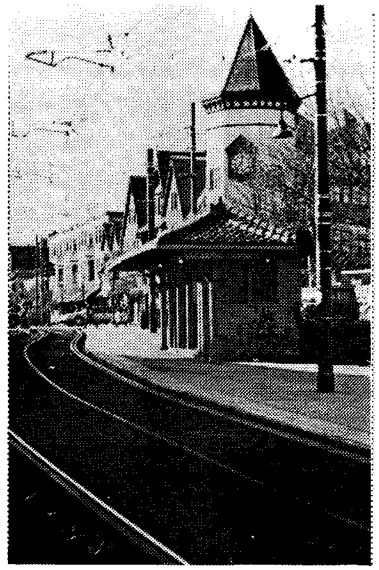


Fig. 2-1
Coolidge Corner

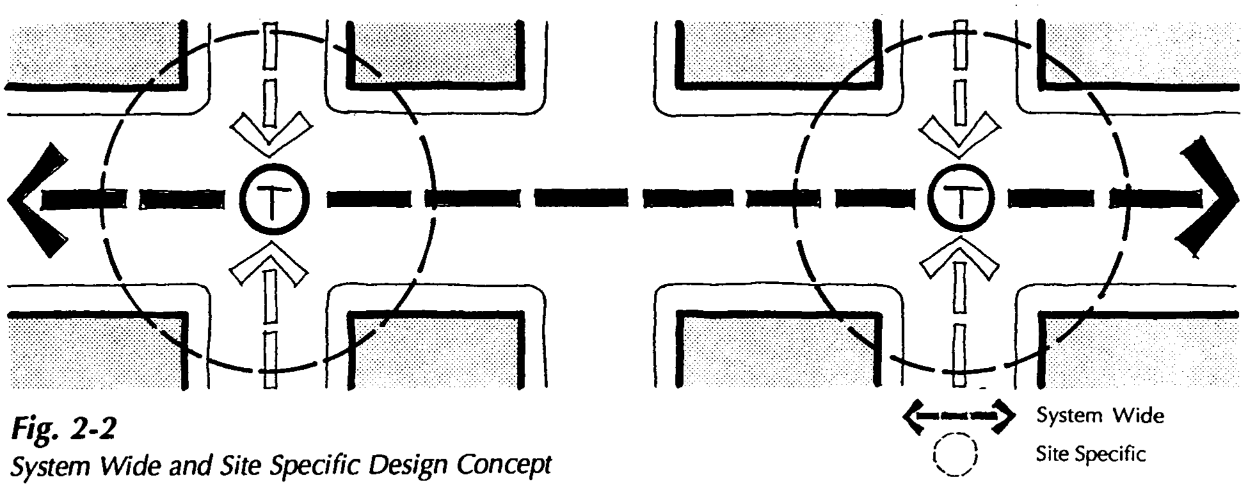


Fig. 2-2
System Wide and Site Specific Design Concept

2.1 Design Objectives

There are two levels of specificity presented: ***guidelines,*** which are meant to direct the final design in a way that meets necessary requirements and reflects the unique character of the immediate context; and ***system-wide elements,*** which present specific design solutions that maintain the integrity of the light rail system. The following chart, ***Fig. 2-3***, categorizes many of the station elements.

ELEMENTS	*SYSTEM WIDE*	*GUIDELINES / SITE SPECIFIC*
• Curb Ramps/ Crosswalks		✔
• Vehicular track crossings	✔	
• Pedestrian track crossings	✔	
• Elevator cabs	✔	
• Elevator headhouses		✔
• Escalators	✔	
• Stairs		✔
• Ramps		✔
• Fare collection equipment	✔	
• Platform paving materials	✔	
• Plaza paving materials		✔
• Track bed treatment	✔	
• Signage	✔	
• Benches	✔	✔
• Trash receptacles	✔	
• Bicycle racks		✔
• Sand storage bins	✔	
• Art work		✔
• Vending machines		✔
• Light fixtures at platform	✔	
• Light fixtures at plaza		✔
• Canopies	✔	✔
• Shelters		✔
• Communication systems	✔	
• Planting		✔
• Planters		✔
• Railings	✔	
• Fencing	✔	
• Vehicular barriers	✔	
• Bollards		✔

Fig. 2-3
Station Elements Chart

2.2.1 Accessible Route

Since the primary task of the project is to provide an accessible transit system, the accessible route(s) both to and within the station must be delineated for each location.

Accessible Route to the Station

Accessible Route to the Station

In order to meet current access requirements it will be necessary to provide an accessible route to each accessible entrance for use of the system. The route shall coincide with the path of travel used by the general public and would include well-lit crosswalks with curb ramps and pedestrian crossing signals at adjacent streets.

In general, this project deals with 3 types of circulation patterns:

- to the street corner entrances, generally for the subways, ***Fig. 2-4;***
- to the center median mid street transitway typical of many surface stations, ***Fig. 2-5;***
- to surface stations located along a dedicated right of way not within the existing street, ***Fig. 2-6.***

The exact accessible route to each of the key stations is delineated in the *Schematic Design Report.*

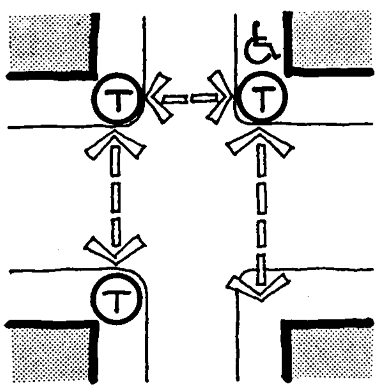


Fig. 2-4
Accessible Route to Subway Entrance

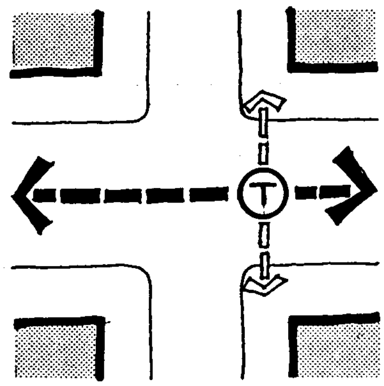


Fig. 2-5
Accessible Route to Surface Station

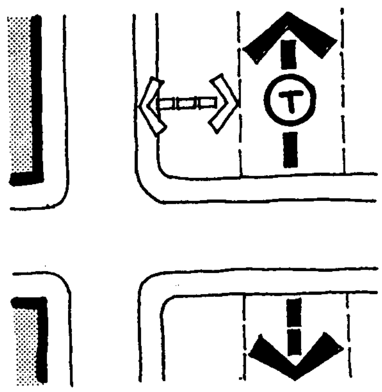


Fig. 2-6
Accessible Route to Off-Street Surface Station

Surface Stations

In order to limit the impact of necessary sidewalk and utility changes, this project defines the limits of the accessible route to the surface stations as access from the closest adjacent street corner. See ***Figs. 2-5*** and ***2-6***.

Since some surface stations span two corners, station architects should consider making both entrances accessible. See ***Fig. 2-7***.

Subway Stations

The accessible entrance to the subway stations will be through an elevator. MBTA policy is to provide one street elevator per station. Station architects should verify compliance with current AAB requirements prior to design. An accessible route shall be provided from the closest adjacent street corner to the elevator.

If an existing subway station has more than one stair or escalator entrance, the accessible route must connect all existing entrance points to the elevator, as well as provide access from the closest adjacent street corner. See ***Fig. 2-5***.

Accessible Route Within The Station

Accessible Route Within The Station

As defined in the *AAB* and in *The MBTA Guide to Access,* an accessible route is "a continuous unobstructed path connecting all elements and spaces in a building or facility. Accessible routes may not include stairs, steps or escalators even if the stairs and steps are required to be accessible under the Regulations."

In this project the accessible route within the stations changes considerably from surface stations to subway stations. Key guidelines for each type are described below.

Surface Stations

Once arriving at the station, the primary goal at surface stations is to move people along the platform from the station entrance or plaza located at one or both ends of the station.

Therefore, the accessible route in most surface stations applies primarily to the route along the platform. Non median stations (Riverside Line) may also involve a grade change. The MBTA policy at surface stations is to achieve this by means of an accessible ramp (see Ramps 2.2.8).

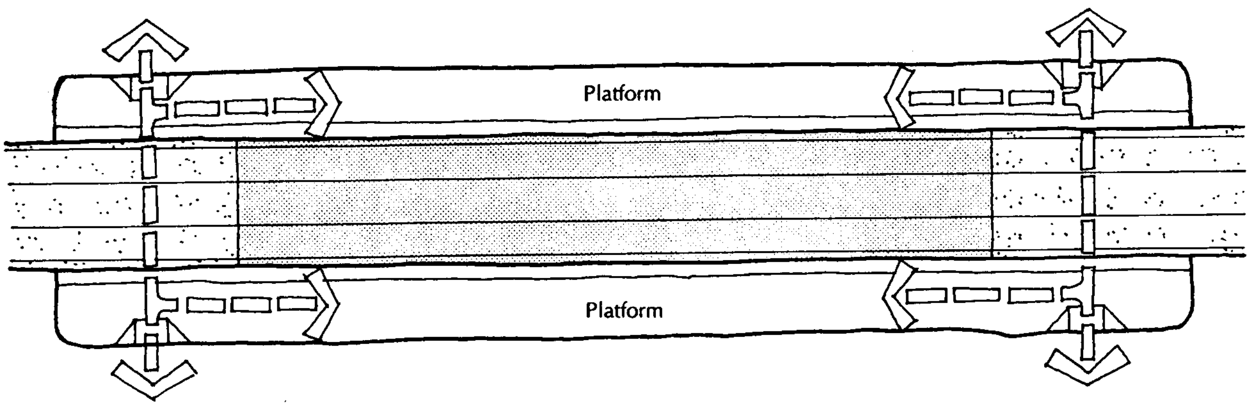


Fig. 2-7
Accessible Route at Surface Stations

Subway Stations

The accessible route within the subway stations is more complicated because it involves a vertical circulation path through one or more level changes.

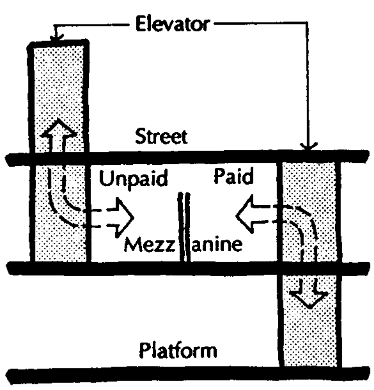


Fig. 2-8
Vertical Circulation With Mezzanine

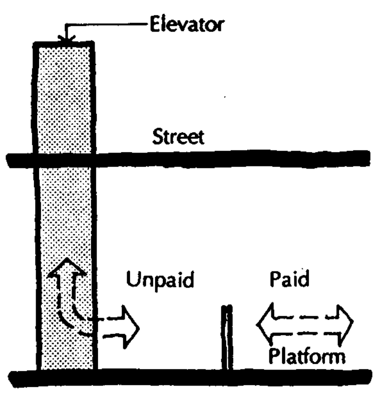


Fig. 2-9
Vertical Circulation Without Mezzanine

It is MBTA policy that level changes are accomplished by means of hydraulic elevators (see Elevators 2.2.5). The *Schematic Design Report* shows options for elevator locations at each of the key subway stations.

The overall access goals for circulation within a subway station are:

1. Provide access from the street to the unpaid lobby, through a fare array, and from the paid lobby to the platform. Access directly to the paid lobby or platform is not acceptable to the MBTA.

2. The accessible entrance and the accessible route should be located as close as possible to the main pedestrian path of travel.

Width of the Accessible Route

Width of the Accessible Route

The minimum width of the accessible route is 36", with a 5' passing zone every 200'. 32" is allowed between certain obstacles. 48" is required if the path is a ramp. See ***Fig. 2-10***. On the platforms, the accessible route may include the 2'-0" tactile warning strip. The 36" width is only applicable in areas where no vehicle ramps will be deployed.

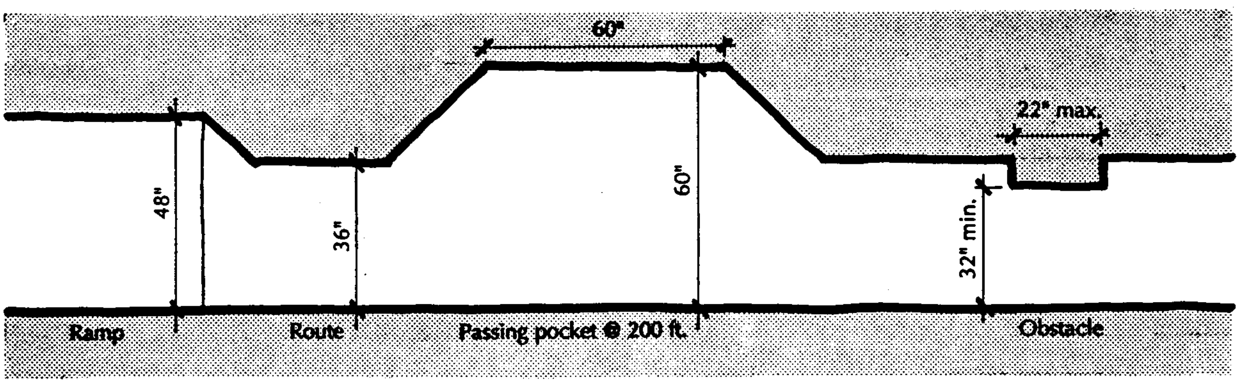


Fig. 2-10
Accessible Route Widths

Width of the Platform Boarding Area

Width of the Platform Boarding Area

The width along the platform is discussed in greater detail in the Platform Section of this Manual. In general the minimum width along the platform boarding area has been developed to allow people in wheelchairs to get on and off the proposed Type 8 vehicles with their projecting ramps, leaving a desired dimension of 5′-1″ at the base of the ramp. This dimension is based on the 5′-0″ ADA guideline for ramp landings plus 1″ for construction tolerance and car position. Although not preferable, a wheel chair can turn in 4′-0″ which provides the basis for the 4′-1″ minimum design width at the bottom of the ramp. This minimum should only be used in extreme conditions where it is not feasible to provide the 5′-1″ dimension.

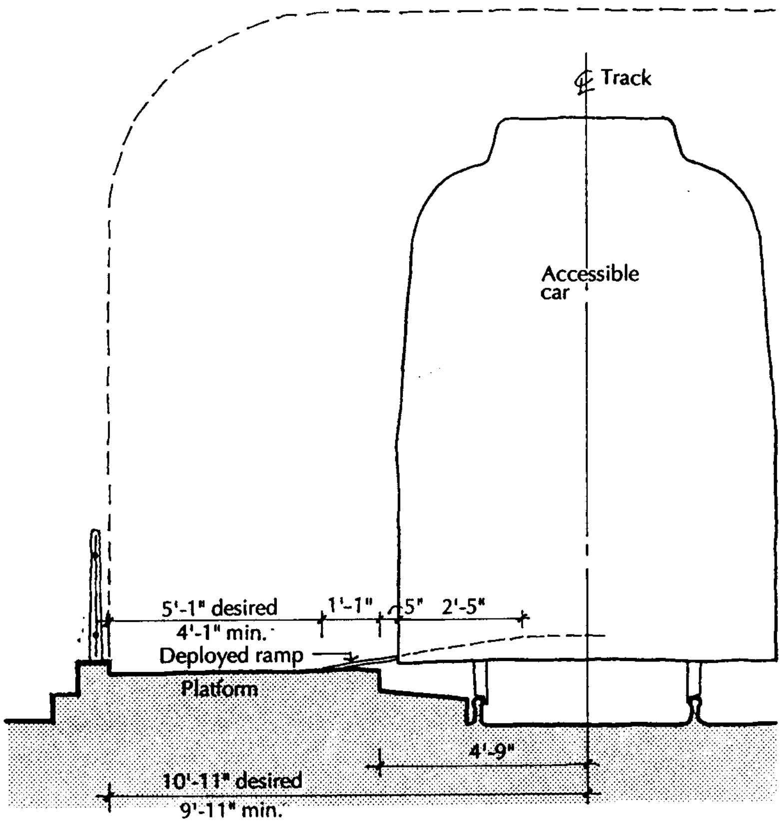


Fig. 2-11
Type 8 Vehicle with Projecting Ramp at Tangent Track

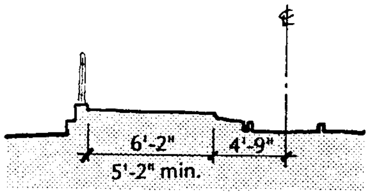


Fig. 2-12
Platform Width at Surface Station

Surface Stations

As previously stated, the preferred width for platforms at a surface station is 6'-2" to a wall or obstacle; the minimum width is 5'-2". At some surface stations, posts or platform furniture can encroach on this space, but only in "clear zone" areas where vehicle ramps will not be projecting onto the platform. ***Fig. 2-13*** delineates the "clear zone" end "ramp zone" areas for surface stations. Appendix 1 gives a more detailed discussion of the "clear zone" and "ramp zone".

The *Schematic Design Report* designates locations where key surface station platforms will be widened in order to meet this guideline.

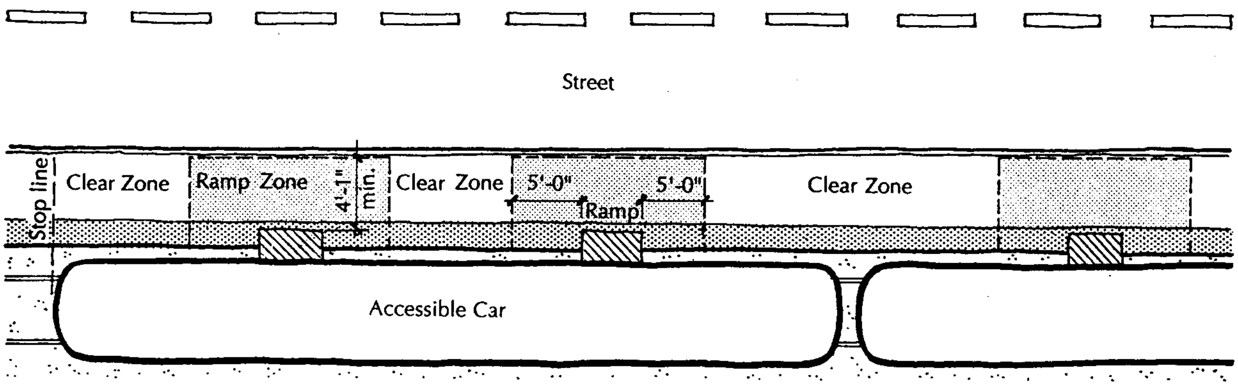


Fig. 2-13
Critical Dimensions at Surface Stations

Subway Stations

The width of the platform boarding area in subway stations is often constrained by the existing columns and stair or escalator walls. When these elements fall within a "ramp zone", a minimum platform width of 5'-2" is required, with 6'-2" preferred.

The *Schematic Design Report* identifies probable column and/or wall relocation at each key subway station where the existing clearances are not available.

Appendix 1 includes some options for minimizing structural impacts including:

1. allowing for multiple train stopping;,
2. limiting ramp deployment to one car per consist,
3. limiting ramp deployment to one side of the train only,
4. limiting the number of cars operating on the platform.

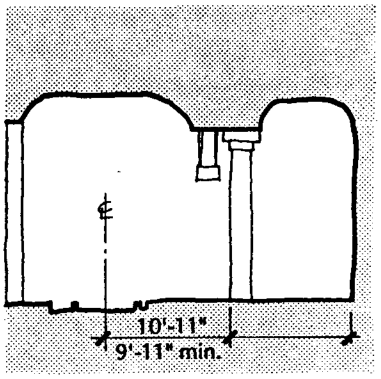


Fig. 2-14
Platform Width at Subway Station

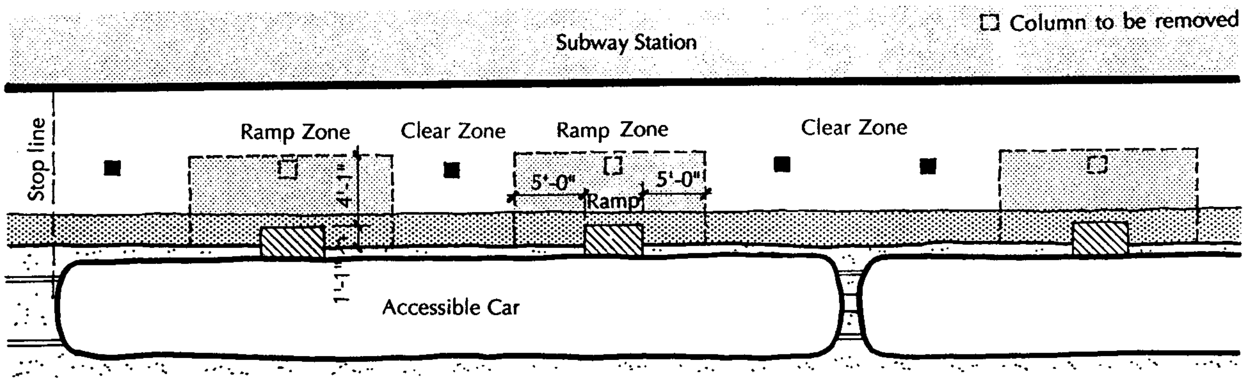


Fig. 2-15
Critical Dimensions in Subway Stations

Slopes

Slopes

The maximum slope along the path of travel is 1:20 or 5%. The maximum cross slope or slope perpendicular to the route or boarding area is 1:50 or 2%.

Changes in level greater than 1/2″ require a ramp. Changes between 1/4″ and 1/2″ may be beveled with a 1:2 slope.

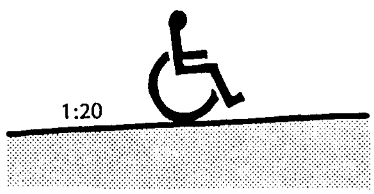


Fig. 2-16
Maximum Path Slope

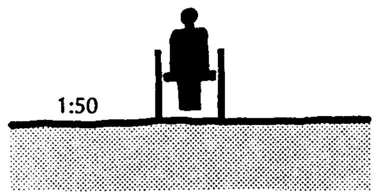


Fig. 2-17
Maximum Cross Slope

Surface Materials

Surface Materials

The surface used along the accessible route shall be made of durable, non-slip materials. Paving materials or unit pavers should be set to create even surfaces with narrow joints and flush edges.

The paving material shall tie into existing adjacent materials and contexts. See the Platform Section of this Manual for system-wide platform materials.

Obstructions and Protruding Objects

Obstructions and Protruding Objects

All objects such as furniture, equipment and telephones should be located beyond 6′-0″ from the edge of the platform. In cases where this is impossible, objects and columns must be located outside the "ramp zones", as far away from the platform edge as possible, still leaving the required 36″ path of travel.

Objects that project out more than 4″ into the accessible route or in areas where visually impaired people using canes may travel, shall be located at least 80″ above the ground.

For example, the brackets holding up canopies in the historic headhouses in Newton Center and Coolidge Corner become problems that require appropriate design solutions. ***Figs. 2-18*** and ***2-19*** make two suggestions.

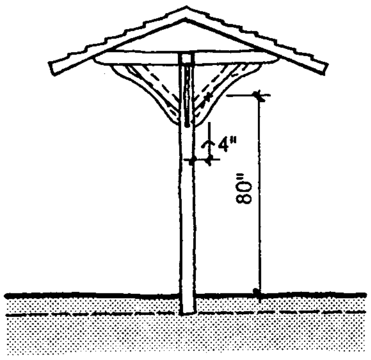


Fig. 2-18
Raised Bracket

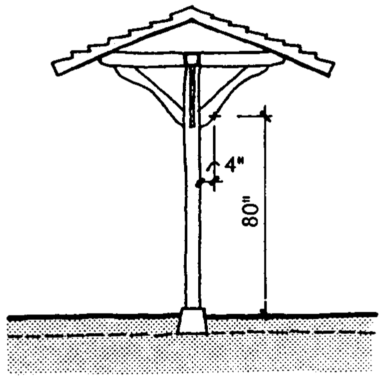


Fig. 2-19
Raised Footing

It should be noted that the MBTA guideline for lighting is 8′-6″ above the ground and for signage is 7′ minimum above the ground so that it is not easily reachable.

Objects mounted on walls along the accessible route, that project out more than 4″, should be easily detected by a person using a cane. Since objects located higher than 27″ off the ground cannot be detected by a cane, hazards can be reduced if elements are recessed or equipped with wing walls which extend to within 27″ off the ground.

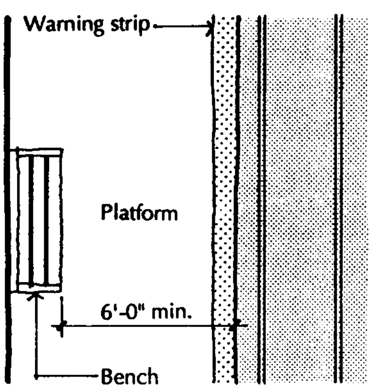


Fig. 2-20
Clear Platform Width

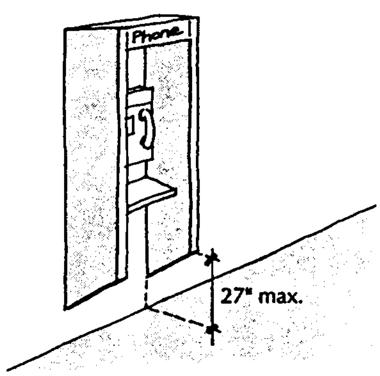


Fig. 2-21
Mounted Objects Along Accessible Route

Utility Covers, Catch Basins, Grates

Utility Covers, Catch Basins, Grates

Utility covers, catch basins and grates should not be located within the accessible route. However, where required within the accessible route, grates shall have a 1/2" maximum open space in the narrow dimension, with the long dimension running perpendicular to the path of travel.

2.2.2 Curb Ramps/Crosswalks

Curb ramps and crosswalks are required elements of the accessible route. There are several parameters to guide their exact location, dimensions and materials, however their final design will be site specific.

Location

Location

The curb ramps and crosswalks should be located along the general path of travel as close as possible to the corner, as this is where most people attempt to cross the street. See ***Fig. 2-22.***

Corner curb ramps are not preferred and may not be allowed in the upcoming AAB regulations. There are however, some exceptions that may be required in this project in order to fit within existing constraints. See ***Fig. 2-33.***

The width of the crosswalk should relate to the usage. It should be noted that AAB does not require that the flared sides be included within the crosswalk, only the ramp itself. However in order to provide visual and pedestrian continuity it is recommended that the entire curb ramp with flared sides be within the crosswalk. This dictates a 15'-0"+ minimum width. ***Fig. 2-22*** show a desired curb ramp, crosswalk configuration. The 5' minimum curb radius is the recommended minimum for granite curbing.

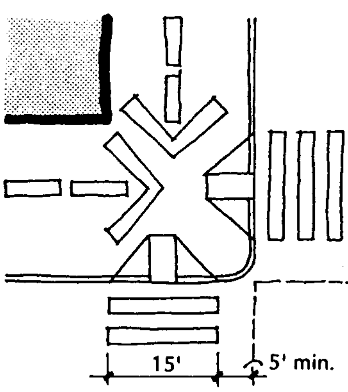


Fig. 2-22
Corner Curb Ramps

Slope

Slope

The *MBTA Guide to Access* requires a 1:12 max. slope for the curb ramp with a 1:12 slope for the flared sides when there is cross traffic or when there is less than 4'-0" to a building or protuberance. ADAAG calls for continuous slopes if the sidewalk is too narrow to fit a standard curb ramp. If there is a non walkable area (planting, etc.) adjacent to a curb ramp the flared side may be eliminated. See ***Figs. 2-23 through 2-26.***

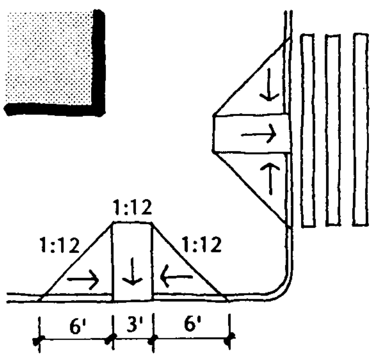


Fig. 2-23
Typical Curb Ramp

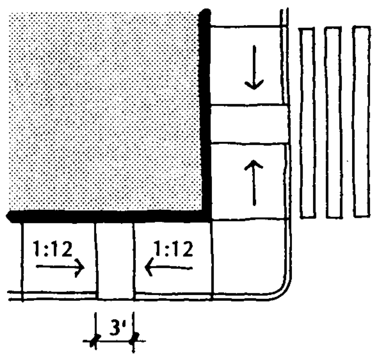


Fig. 2-24
Curb Ramp at Narrow Sidewalk

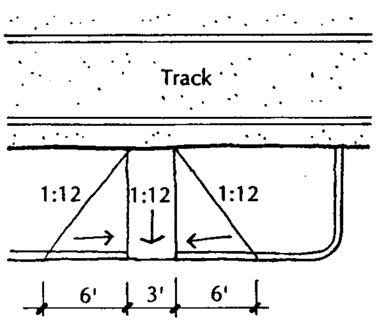


Fig. 2-25
Curb Ramp at Narrow Surface Platform

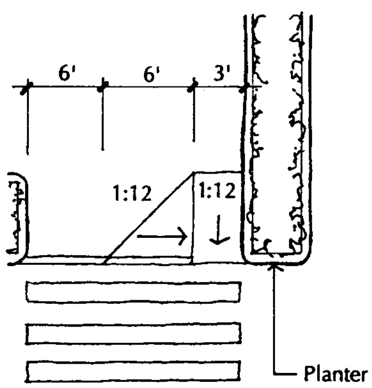


Fig. 2-26
Curb Ramp Adjacent to Non-Walkable Surface

Materials

Materials

Curb ramp and crosswalk materials are to be site specific to tie into the existing context and MBTA plaza or platform material. There are certain nodal stations where the curb ramp and crosswalk should be paved in order to focus attention on the importance of the station and to tie the path into existing sidewalk materials.

Paving materials used for designing special crosswalks shall create even surfaces with narrow joints and flush edges.

Unpaved crosswalks will have the standard white painted strip.

Station Architects working with the MBTA and local officials should determine which stations are candidates for paved crosswalks.

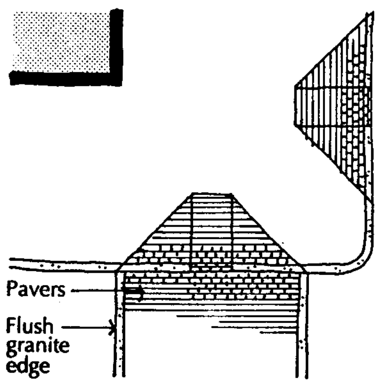


Fig. 2-27
Paved Crosswalk, Alternate

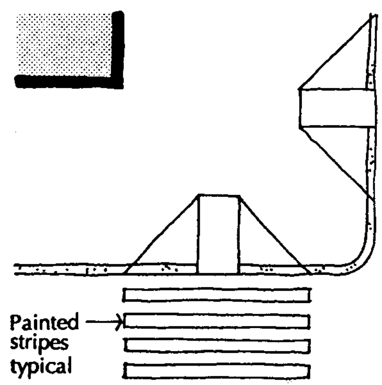


Fig. 2-28
Painted Strip Crosswalk, typical

Prototypical Curb Ramps and Crosswalks

Prototypical Curb Ramps and Crosswalks

There are several curb ramp and crosswalk prototypes that will exist throughout the line. ***Figs. 2-29 through 2-31*** illustrate guidelines.

Narrow Platforms

On narrow platforms the intersections of the curb ramp, warning strip, stops and track materials are critical. Two options are available.

Fig. 2-29 shows a typical crosswalk at a narrow platform. The 10' - 11" minimum from center line of track to the barrier is the governing dimension. A 5'-0" level area between the curb/ramp and the 1:20 pathway slope up the platform is preferred, if space is available. At narrow platforms the slope of the curb ramp can begin 4'-4" from the center line of the rail. This is determined by the outer edge of the rubber grade crossing. The dimension may vary if a precast crossing is used. See Section 2.2.3 - Vehicular Crossings.

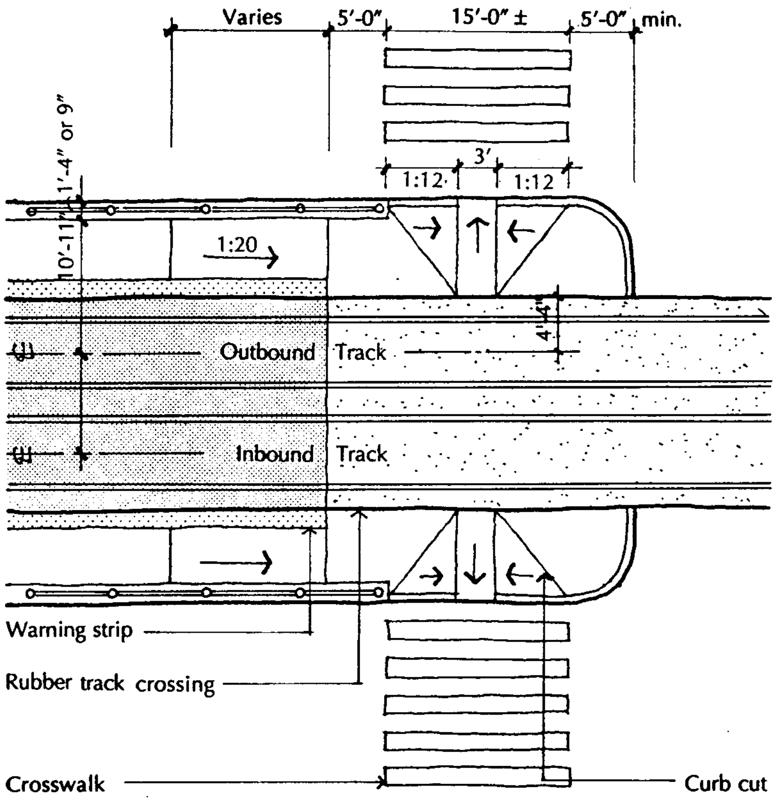


Fig. 2-29
Prototypical Crosswalk at Narrow Platform

Fig. 2-30 shows options for a raised planting or paving area adjacent to the curb ramp, thereby eliminating one of the flared sides.

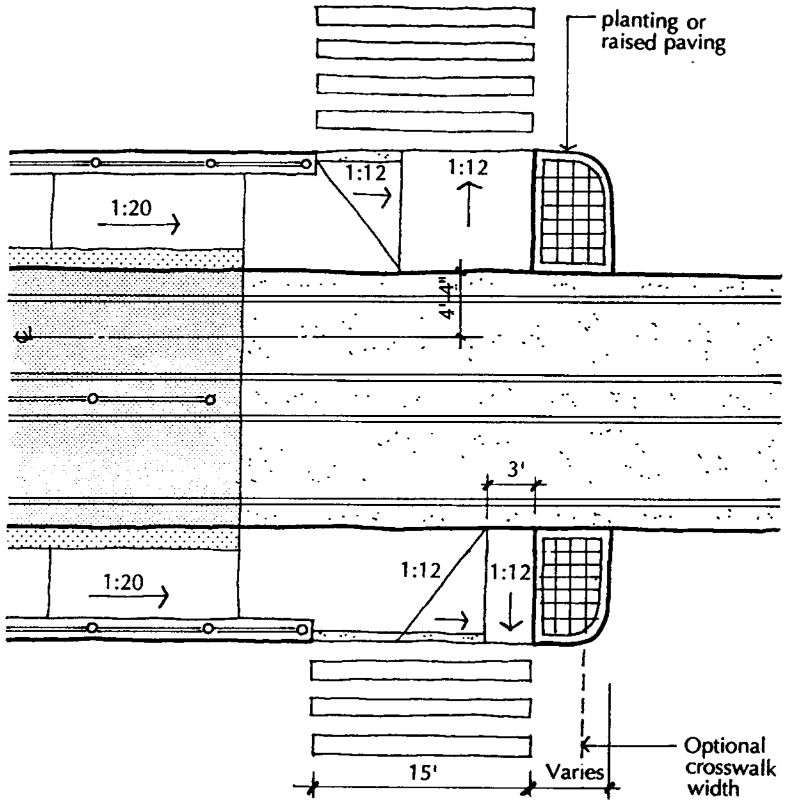
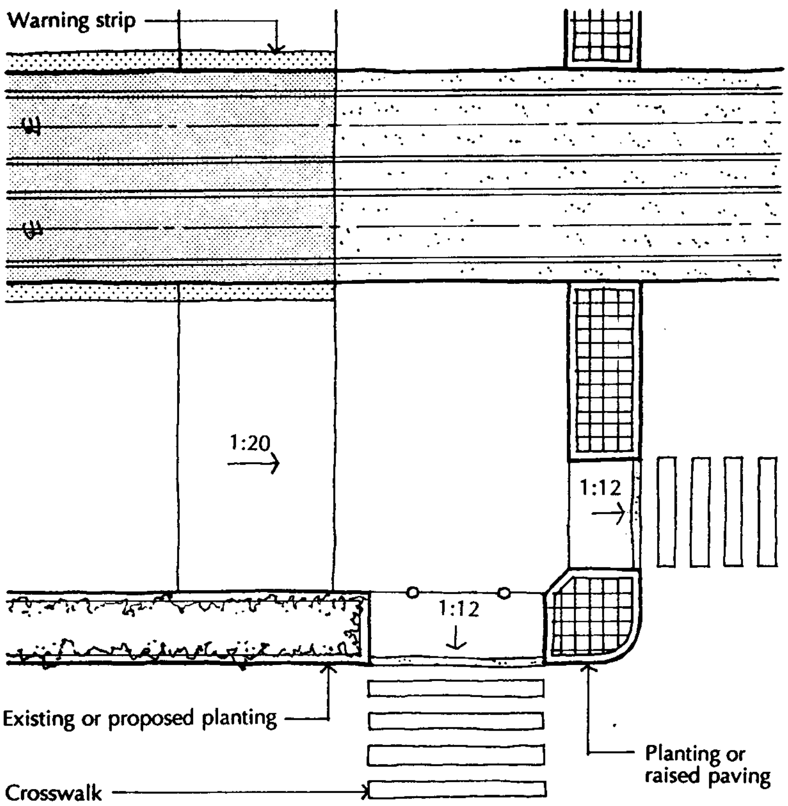


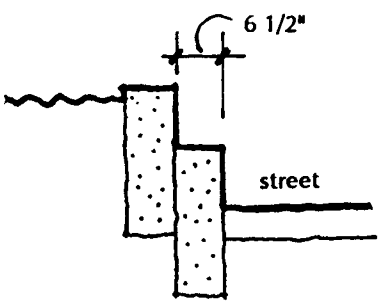
Fig. 2-30
Prototypical Crosswalk at Narrow Platform with Raised Planting or Paving

Wide Platforms

In cases where planting buffers or raised areas can be designed or exist along a curb ramp, a returned curb ramp, without the flared sides is permitted. There are several options for crosswalks where planting buffers exist or are proposed.



Prototypical Crosswalk at Buffer



Detail of Typical Planting Edge
Fig. 2-31

Posts/Manholes/Signals

Posts/Manholes/Signals

Light posts, signals and man holes should be located outside the path of travel. See ***Fig. 2-32***.

Atypical Conditions

Atypical Conditions

Even though the Draft AAB does not permit corner curb ramps, there are several situations where perpendicular curb ramps are physically impossible. However, it is possible to locate a single curb cut so that it is adequately within the path of travel. In these cases a 4' - 0" minimum dimension is required from the edge of the curb cut to the edge of the crosswalk. ***Fig. 2-33*** illustrates this.

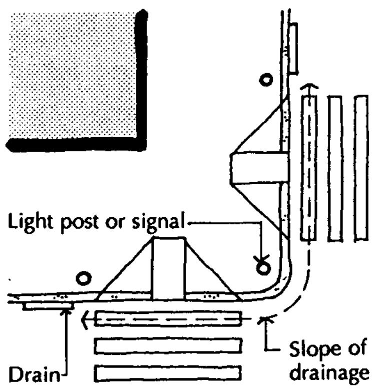


Fig. 2-32
Posts/Manholes/Signals Location at Curb Ramps

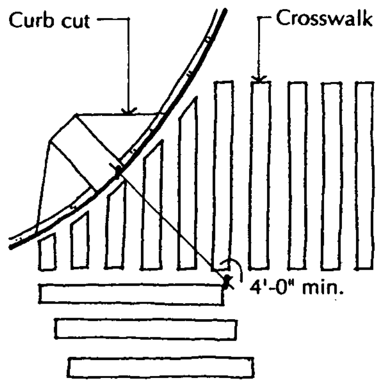


Fig. 2-33
Curb Ramp Serving Two Crosswalks

2.2.3 Pedestrian/Vehicular Track Crossings

The MBTA standard material for vehicular track crossings is their "full depth rubber track crossing". This material currently exists in many surface stations and is expected to be used as a system-wide material in this project. A precast concrete crossing material is also being explored by the MBTA.

Fig. 2-34
Asphalt Track Crossing at Cleveland Circle

Figs. 2-34 and ***2-36*** show examples of existing track crossing conditions. In order to make a substantial improvement on the visual quality of the streetscape, asphalt crossings should be replaced, wherever possible, with the "full depth rubber track crossing" material. In areas where the curved radius is less than ±800', the rubber track crossing material cannot be used. Bituminous concrete will have to be used.

At station plazas, the MBTA is currently suggesting that this material extend into the pedestrian crossing in such a way to align with the path of travel or with the beginning of the platform slope, which ever is furthest. See ***Fig. 2-35.***

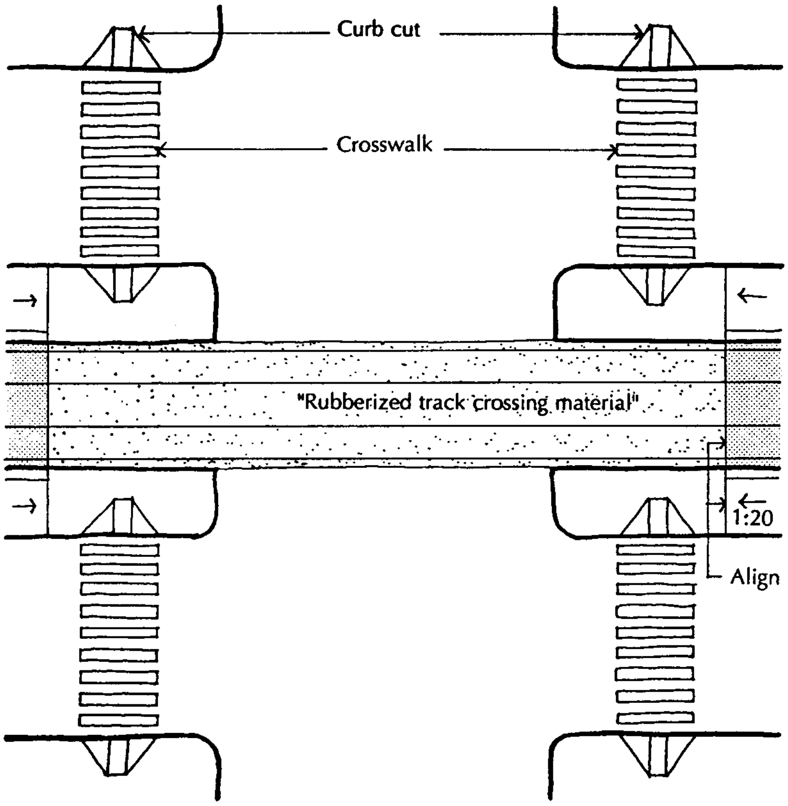


Fig. 2-35
Track Crossings at Station Plazas

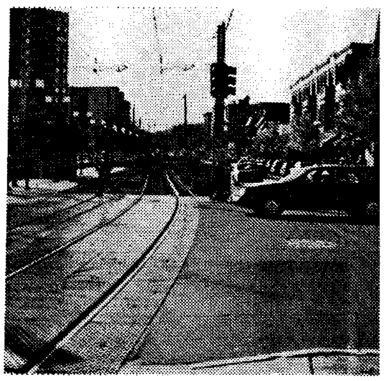


Fig. 2-36
Rubberized Track Crossing at Coolidge Corner

2.2.4 Pedestrian Track Crossings

Fig. 2-37
Pedestrian Track Crossing at Coolidge Corner

Pedestrian track crossings occur at all surface stations and at Park Street Station connecting the eastbound platforms. In order to avoid potential conflicts between pedestrian and rail traffic, pedestrian crossings should be located at specific locations. Mid-track fencing (See 2.11 Barriers) may be installed at certain locations to help limit track crossings. Their exact location, size, and material will be based on site specific conditions.

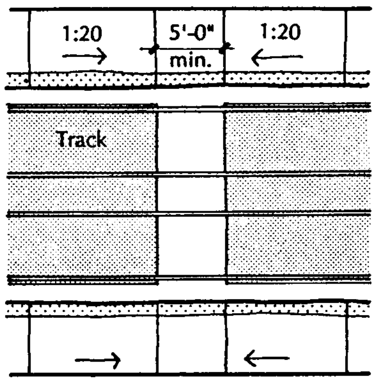


Fig. 2-38
Accessible Mid-Track Crossing with 1:20 slopes

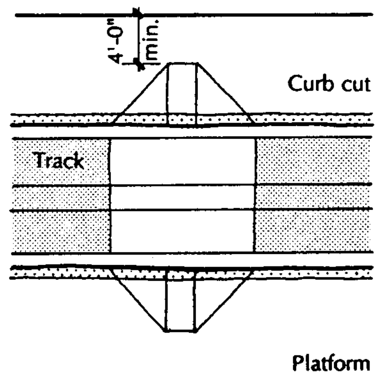


Fig. 2-39
Accessible Mid-Track Crossing with Curb Ramps

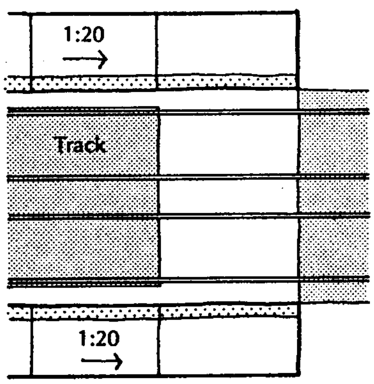


Fig. 2-40
AccessibleEnd of Track Crossing

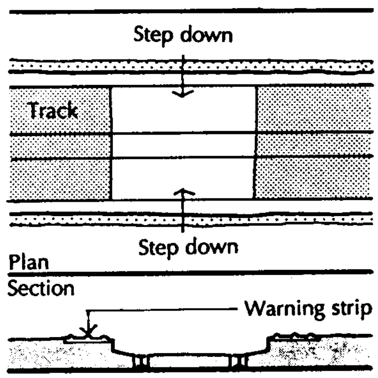


Fig. 2-41
Non-Accessible Stepped Crossing

Pedestrian/Vehicular Track Crossings

Pedestrian/Vehicular Track Crossings

Where accessible pedestrian crossings are contiguous with vehicular crossings, the MBTA is currently suggesting that the same rubber or precast material extend into the pedestrian zone. See ***Fig. 2-35***. This material should extend into the plaza or crossing area for the total width of the accessible route, as defined by the probable path of travel. However, station architects may consider the option of continuing the plaza or platform paving in this area in order to separate the pedestrian/vehicular zones.

Accessible Mid-Track Crossings - *Figs. 2-38, 2-39, & 2-42*

Accessible Mid-Track Crossings

Mid-track crossings, accessible to people who use wheelchairs, are not preferred as they create conflicts between pedestrian and vehicular movements especially when a stopped car blocks the crossing. However, there are some cases where mid-track crossings may be required.

These crossings require 1:12 curb ramps or 1:20 slopes and should be carefully located in order to take into account the "wavy" platform effect.

Because these crossing are located along a boarding area, the tactile material should continue. The crossings should be made out of the MBTA standard rubber or precast crossing, material.

Accessible End of Track Crossings - *Figs. 2-40 & 2-42*

Accessible End of Track Crossings

Accessible track crossings not located contiguous with a street are to be located, whenever possible, at either end of the train. Train lengths and stop lines are illustrated in the *Schematic Design Report.*

The width of these crossings should be determined by probable usage. The material should be the MBTA standard rubber or precast crossing material.

Non-Accessible Stepped Crossings - *Figs. 2-41, 2-43, & 2-44*

Non- Accessible Stepped Crossings

Mid-track crossings that are not required for people in wheelchairs will require a 6" step down and up to cross the tracks.

The location and width of these crossings, either sporadic or continuous, should be coordinated with the MBTA.

The material should be the MBTA standard rubber or precast crossing material.

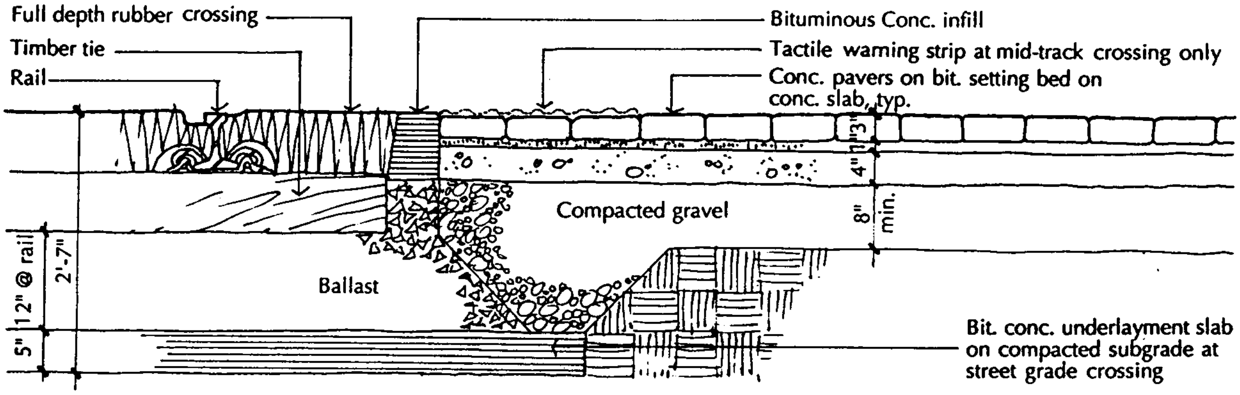


Fig. 2-42
Detail at Accessible Track Crossings

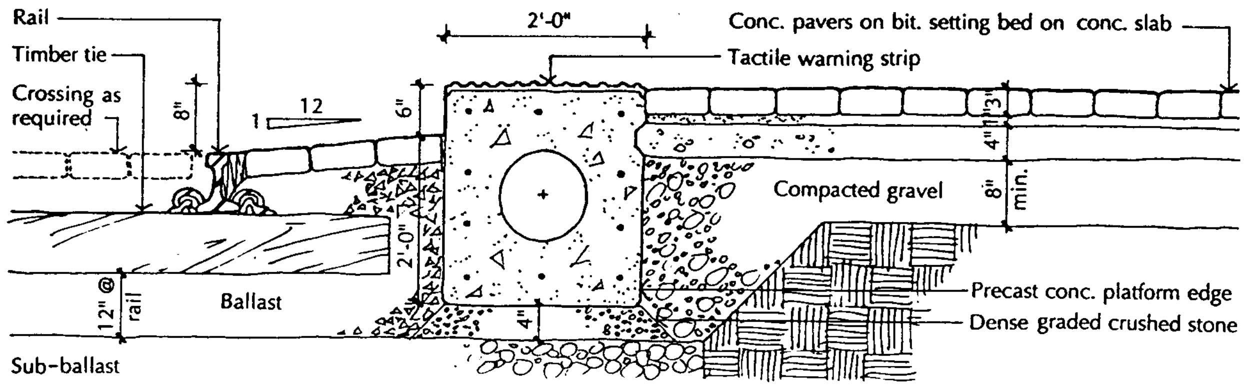


Fig. 2-43
Detail at Non-Accessible Stepped Track Crossing - Surface Station

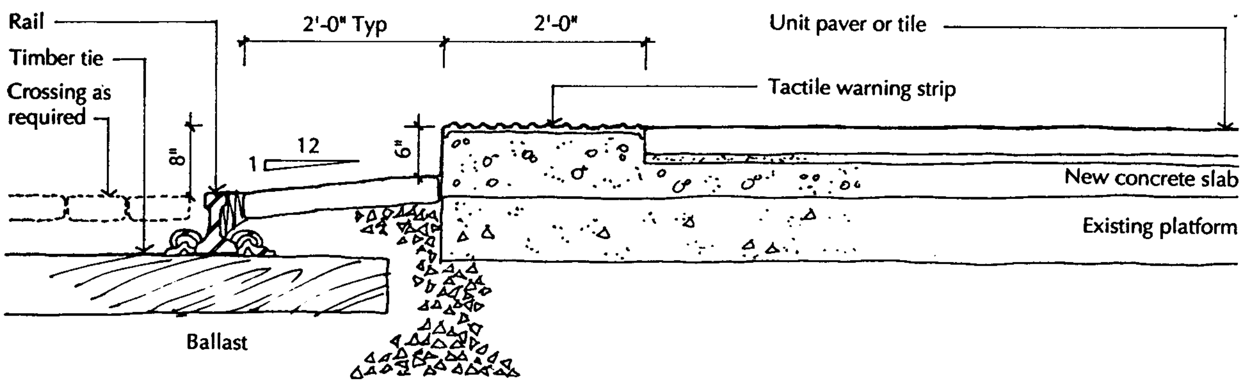


Fig. 2-44
Detail at Non-Accessible Stepped Track Crossing - Subway Station

2.2.5 Elevators

Elevators will be required at all key subway stations for vertical circulation from the street to the unpaid mezzanine or lobby, and/or from the paid mezzanine to the platform. In general, the elevator headhouse, should be site specific, whereas the cab should be used system-wide.

The following assumptions have been made concerning elevators for use in this project.

1. Accessible vertical circulation shall be accomplished by means of hydraulic elevators.

2. Even if there are several existing street entrances, only one elevator would be required to each platform. Station architects should verify this with the MBTA prior to design.

3. It is MBTA policy that the street elevator go directly to the unpaid lobby, and that the mezzanine elevator(s), if required, go from the paid lobby to the platform. (See ***Figs. 2-8*** and ***2-9***)

4. Elevators should be located along the primary path of travel and should be as transparent as possible.

All elevators installed prior to the accessibility project will have to be adjusted to meet the proposed raised 8" platform height.

Design Criteria and Goals

Design Criteria and Goals

Alternate elevator locations are shown in the *Schematic Design Report* for each of the key stations. Urban Design considerations at the street level will be critical in determining the final location and image of elevator headhouses, since these structures are large and will often be located in sensitive historic contexts. Safe and easy use of the elevator are also important design goals for determining final location and design of the elevators on all levels of the system. A summary of the design considerations for the elevators follows.

1. Adjacency constraints, especially in historic contexts, will dictate that, although there will be some common elements, the overall form of each street headhouse should compliment the existing context. At the most sensitive locations, every effort should be made to locate elevator headhouses within existing buildings to avoid the real conflicts that will appear when locating the headhouse in the streetscape.

2. The street elevator headhouse should be located and designed to:

   a. maintain important views and sidewalk widths.
   b. keep street corners open.
   c. intrude as little as possible on the existing urban fabric by maintaining the integrity of the streetscape and adjacent building facades.
   d. keep adjacent store frontage open in order to avoid decreased real estate values and maintain existing retail exposure.

3. The elevator headhouses and cabs at all levels should be located and designed to be as transparent as possible in order to help mitigate the obvious safety problems associated with small enclosed spaces, and thus to provide safe usage.

Elevator Cab Size

Elevator Cab Size

There are 3 acceptable interior dimensions for the elevator cab in key station alterations:

- 51x80 inches, if the door is centered;
- 51x68 inches if the door is off-center;
- and a cab sized to allow a 60 inch circle to be inscribed.

General sizes for the minimum cabs and headhouses are shown in ***Fig. 2-45***.

The final outside headhouse dimensions will depend on the elevator manufacturer, the type of elevator rail system (side or diagonal), the type of doors , and the support system used.

Elevator Cab Design and Materials

Elevator Cab Design and Materials

In order to maintain system wide continuity and to ease maintenance, it is expected that all elevator cabs should be based on the same design, using the same materials. ***Fig. 2-46*** shows the prototypical interior elevations for the elevator cabs.

- Glass panels should be made of 9/16 inch laminated safety glass. They should be as large as possible, with a minimum number of mullions for easy cleaning.

- Mullions, panel boxes, ceilings and wall surfaces should be brushed stainless steel.

- Floor material should be moisture resistant and non-slip.

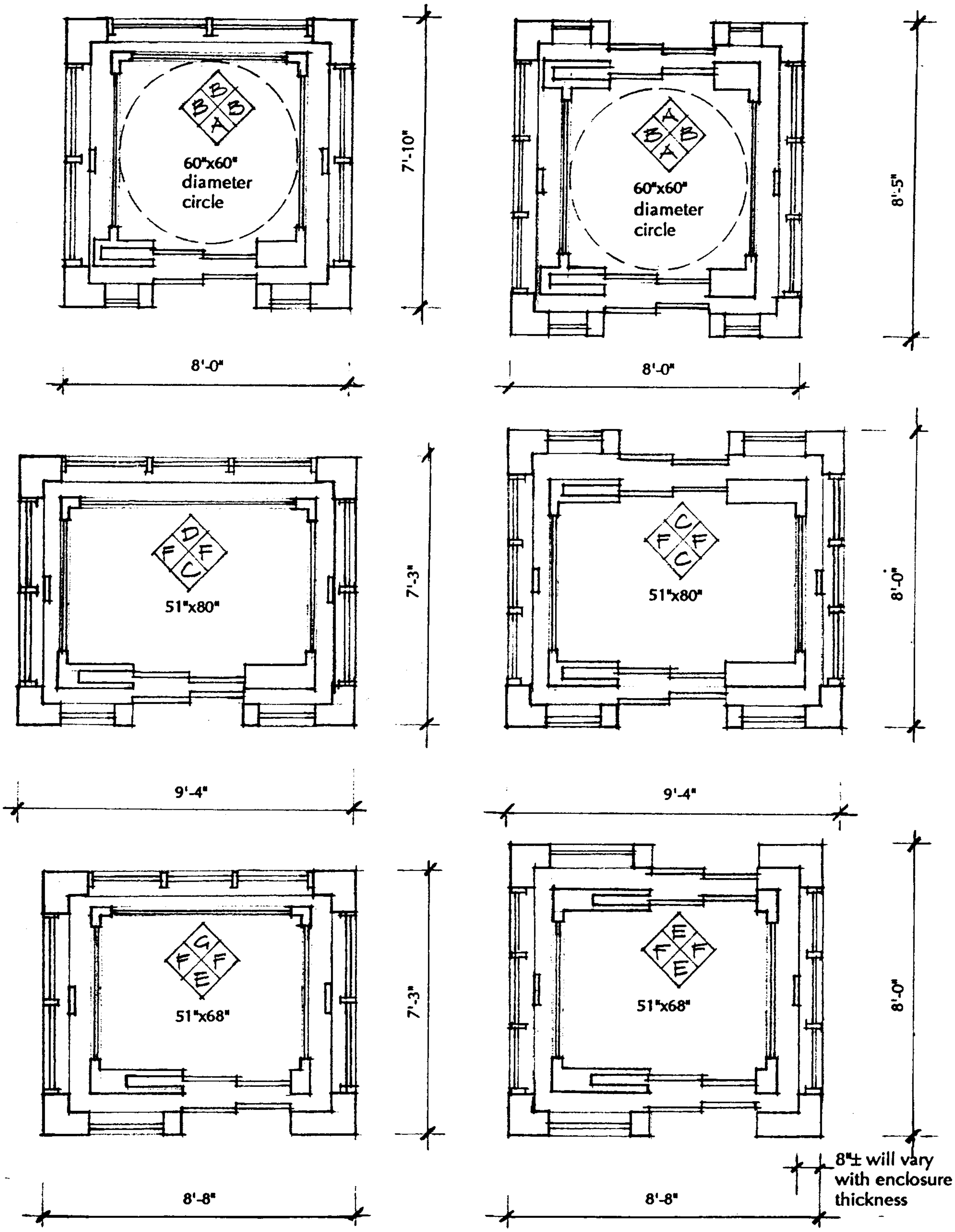


Fig. 2-45
Elevator Cab Plans - Standard Hydraulic with Wide Supports

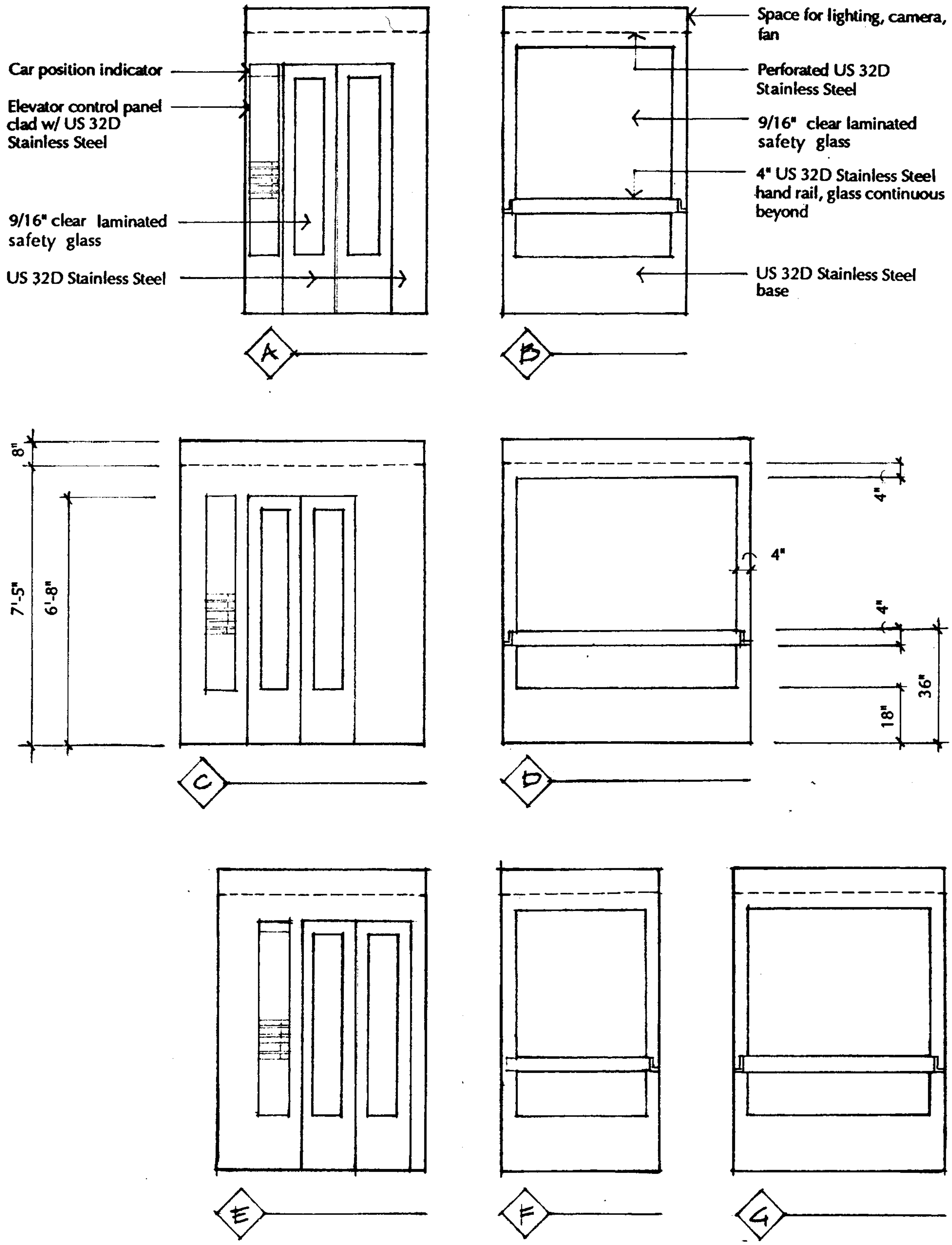


Fig. 2-46
Prototypical Interior Elevator Cab Elevations

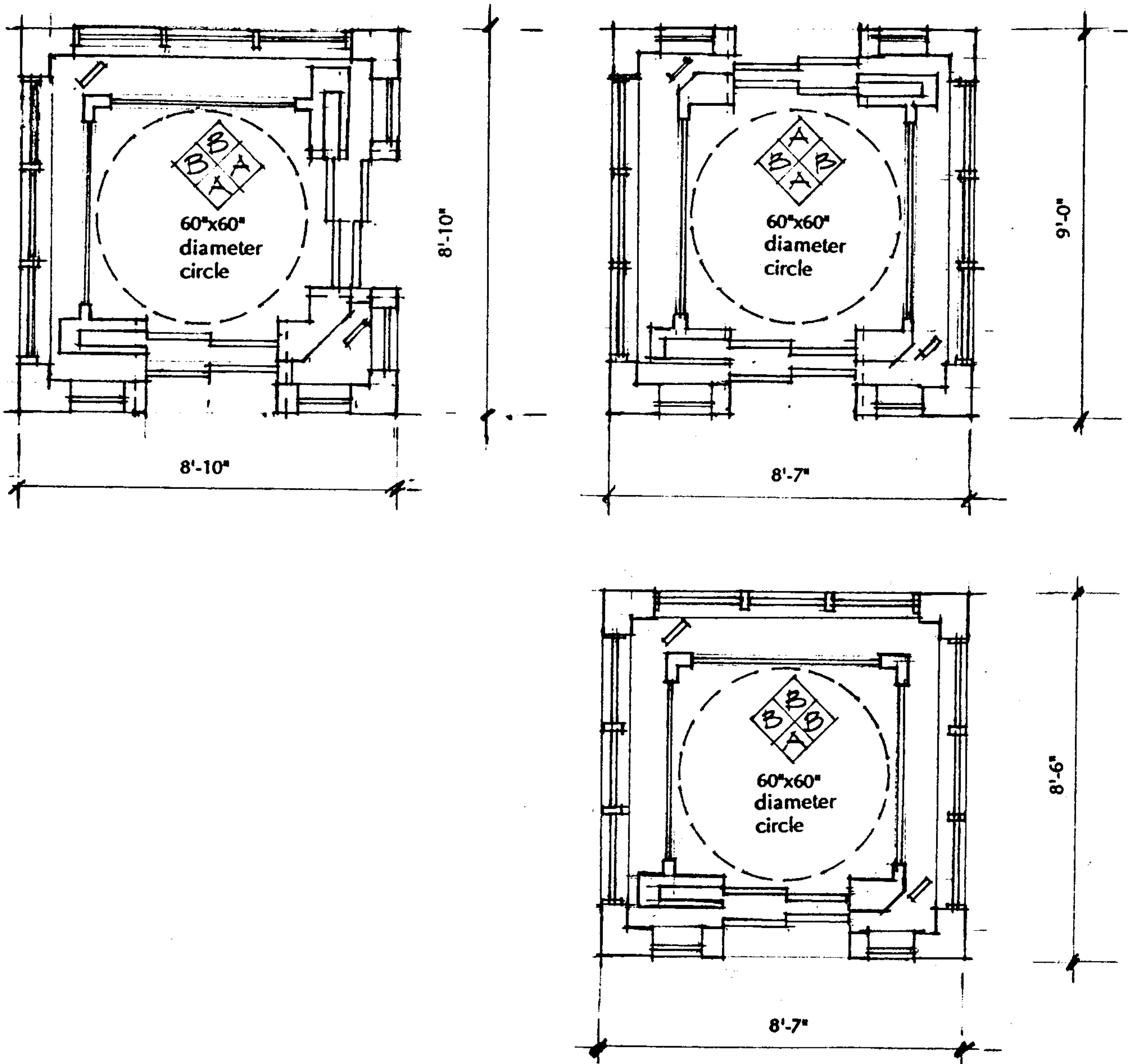


Fig. 2-47

Elevator Cab Plans - Standard Hydraulic Corner Supports, 60" Diameter

Height/Structure

Height/Structure

The exact height of the elevator shaft is a function of the cab size and the requirements of the Elevator Code for required over runs. In general a distance of 3'-0" is required both above and below the cab. See ***Fig. 2-48***.
Existing conditions will need to be studied at each elevator location for possible structural and headroom constraints.

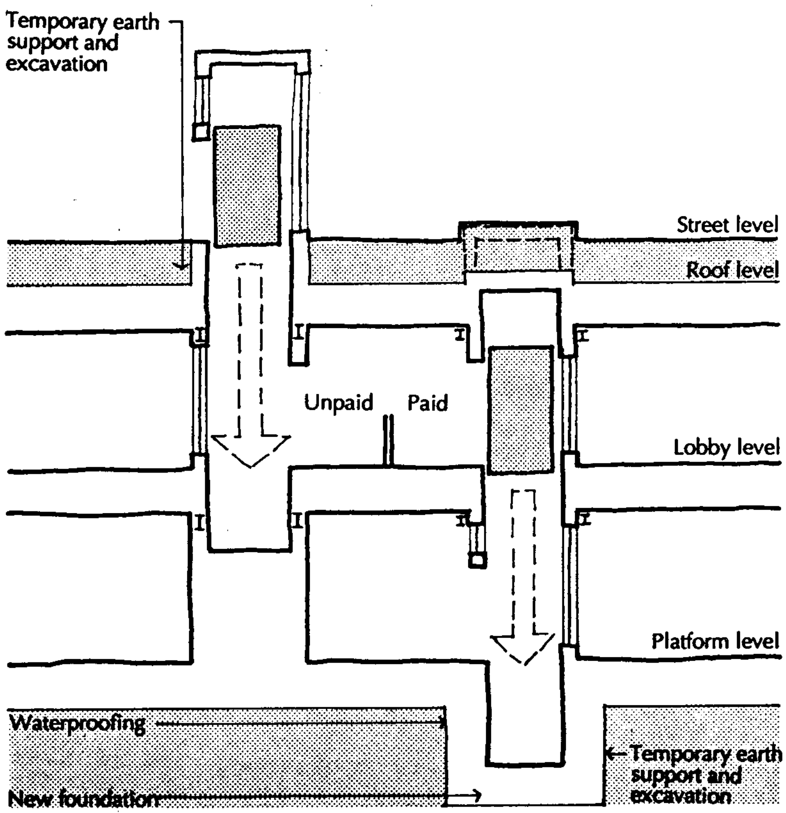


Fig. 2-48
Elevator Cab Section

Elevator Systems and Controls

Elevator Systems and Controls

Refer to the *MBTA Guide to Access* for location of handrails, call buttons, control panels, emergency systems, and other mechanical requirements. The location of the elevator mechanical room and venting are also important design parameters.

Elevator Headhouse Design and Material

Elevator Headhouse Design and Material

New elevator headhouses will be required at all existing Green line subway stations. These head houses should not be system wide, but rather should take their design form from their contexts.

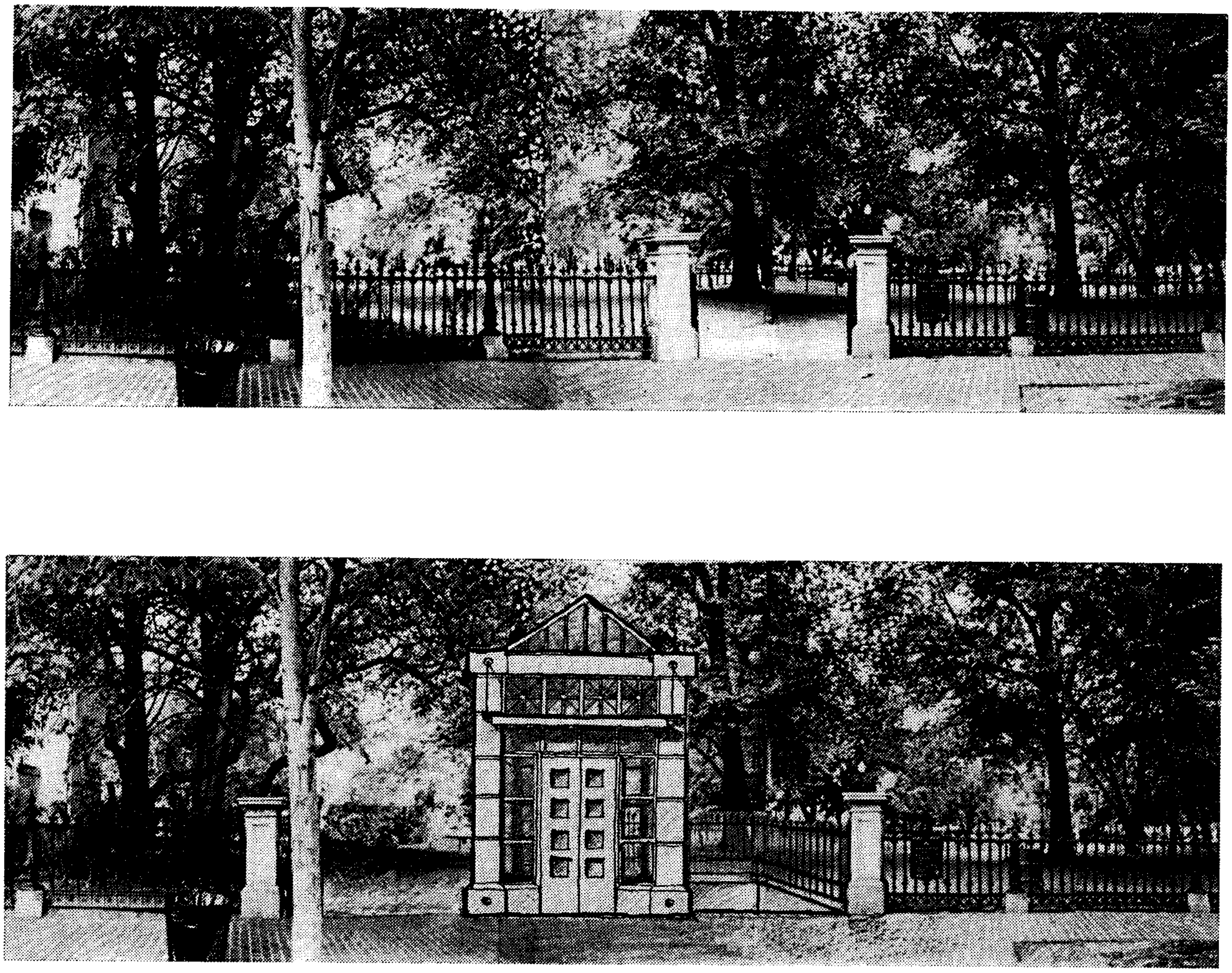


Fig. 2-49
Image study for possible elevator headhouse at Arlington Street

Fig. 2-50 shows the inbound Copley headhouse, an example of a transit headhouse that works well within its context. *Fig. 2-51* shows the outbound Copley headhouse as an example of a transit headhouse that blocks views of an important building and blocks pedestrian access along an important street.

General guidelines for materials include:

- glass panels of 9/16 laminated safety glass. Glass to be located on as many sides as possible in order to make the headhouses as transparent as possible.
- stainless steel doors, with as much glass as possible, to avoid any hidden views. This may require a variance from the Elevator Board, but is critical to surveillance and safety, especially when space limits glass panels adjacent to the doors.
- solid bases at 1'-0' from the surface.
- all elevator headhouses will be required to have a covered entrance.
- masonry , wrought iron or steel framing.
- copper, lead coated copper or translucent roofs.

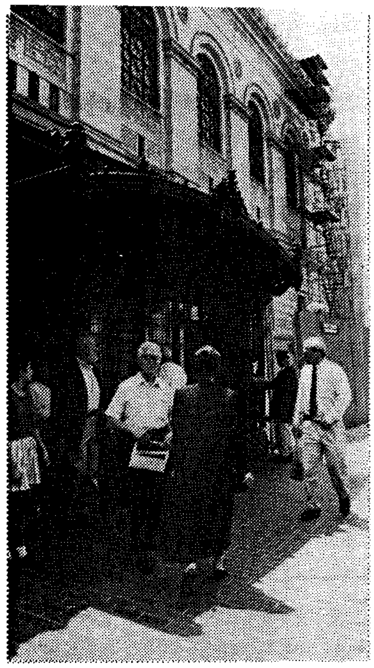


Fig. 2-50
Headhouse at Copley Inbound

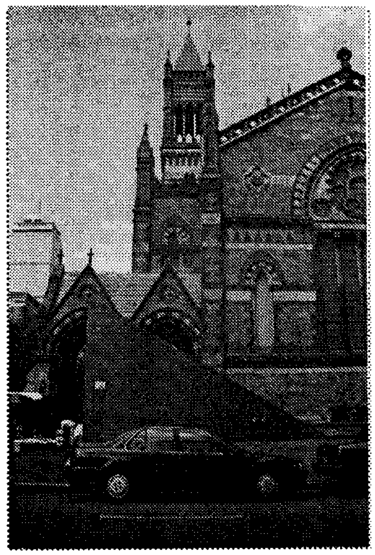


Fig. 2-51
Headhouse at Copley Outbound

2.2.6 Escalators

All of the key subway stations have escalators, either connecting the street to the mezzanine or platform, and/or connecting the mezzanine to the platform.

There are no AAB or MBTA Access Guidelines concerning escalators, however ADA Guidelines require escalators in new construction to have a minimum clear width of 32" with 2 contiguous level treads at the top and bottom and 2" strips of contrasting color at each tread.

The MBTA is currently preparing standards for heavy duty transit type escalators based on APTA guidelines. The station architect should coordinate with the MBTA.

Replace Escalators

Replace Escalators

Escalators which intersect with raised platforms will be affected by this project. It is expected that these escalators will need to be replaced in order to discharge at the higher level. Preliminary studies have indicated that all escalators will need to be replaced at key stations, as there is not enough space to provide ramps without creating a "wavy" platform. However, station architects for future stations should explore the possibility of ramping to existing escalators.

Escalators that need to be replaced should attempt to meet the above mentioned ADA guidelines. However, because escalators are not part of the accessible route and because the work is considered an alteration and not new construction, there is no expectation that structural walls will need to be relocated if 32" of clear width is not available.

Headroom

Headroom

Station architects should study headroom constraints where escalators need to be raised.

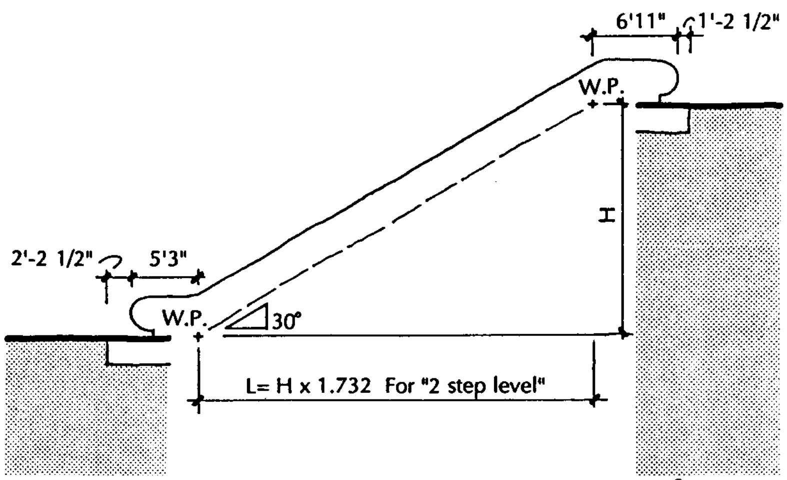


Fig. 2-52
Escalator Dimensions

2.2.7 Stairs

Major stairways exist throughout the system: as entrances to and within subway stations, and at surface stations - Newton Center, Fenway, Boston College and Reservoir. Minor stairways may be required at other stations as well. Stair design will be site specific based on the guidelines presented below and in the *MBTA Guide to Access.*

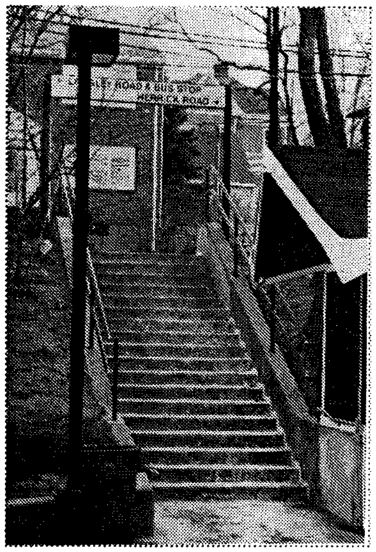


Fig. 2-53
Existing Stairs at Newton Center

Currently it is assumed that some, if not all, of the station modifications will trigger the AAB regulation that requires all stairways to meet accessibility guidelines. Final determination should take place after preliminary costs have been determined.

An initial survey (see *Schematic Design Report Appendix*) suggests that structural changes will not be required. Compliance can be obtained, if required through modification of the risers, treads and handrails.

Station architects will be required to verify existing risers, treads, materials, and handrails as to their conformance.

Interfaces with the raised 8" platform height will also create necessary stairway modifications. Some of these changes are described below.

Risers/Treads

Risers/Treads

Risers and treads should be designed or modified to have uniform dimensions and to comply with the current *MBTA Guide to Access.* See ***Fig. 2-54.***

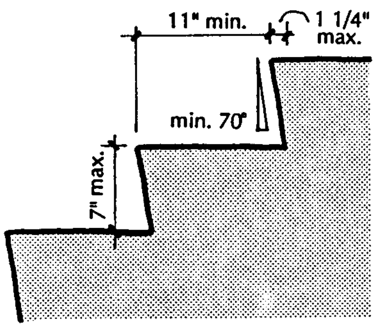


Fig. 2-54
Riser/Tread Detail

Fig. 2-55
Tread Covering

Open Risers

Open Risers

Open risers are not permitted. However, where visual access is required, especially if an elevator is located behind, a perforated grill type riser should be considered. See *Fig. 2-56.*

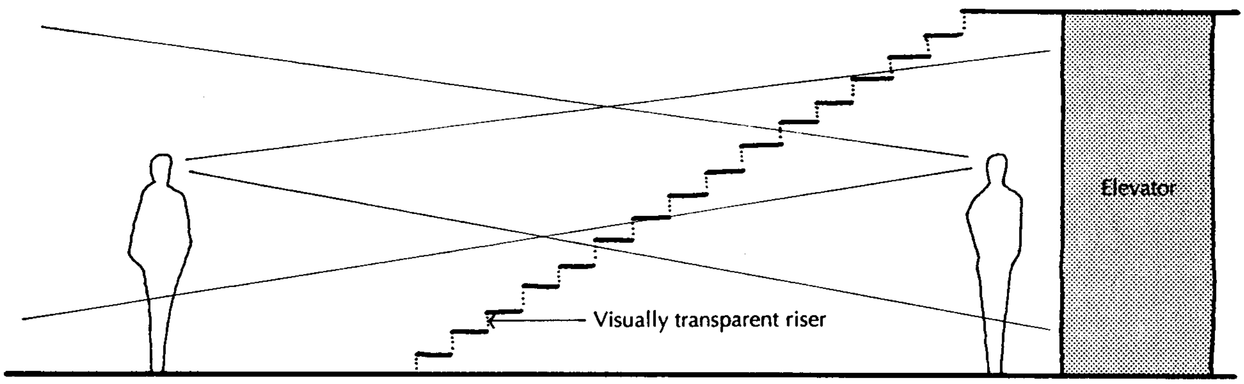


Fig. 2-56
Open Risers Stairway

Materials

Materials

Materials should be selected on a site by site case to tie into adjacent paving materials.

Rubber treads and nosings are not preferred. The MBTA is currently using a material called "Amstep" as a renovation material, although appropriate tile, or pavers are also being used.

Stairs at Raised Platforms

Stairs at Raised Platforms

Existing stairs will be affected when they intersect with the raised platforms. This occurs at almost all of the subway stations and some surface stations. In some stations, stairs are affected both upon entering the platform level and transferring to other levels below the platform. See ***Fig. 2-57***.

The increase in platform height will probably eliminate the first riser of adjacent stairs. At locations where the raised platform intersects a descending staircase, a new riser would be required. ***Fig. 2-57*** illustrates both those conditions.

The governing requirements are to create equal riser heights with the appropriate profile. (See *MBTA Guide to Access.*) A 1:20 slope upward or downward at the first or last riser is acceptable. If the raised platform height is such that equal risers cannot be achieved, the stairway may need to be rebuilt.

Handrails

Handrails

Handrails on all stairs adjacent to raised platforms will require study on a site by site basis. In many cases the entire handrail will need replacement as a modification will be impractical. See ***Fig. 2-58.***

Handrails along stairs shall be designed as per details and guidelines in the *MBTA Guide to Access.* The MBTA prefers all handrails to be made out of stainless steel tubing or other non-painted, maintenance free material. Galvanized steel will eventually rust and is not preferred, but is permitted.

Fig. 2-58 illustrates an existing handrail that will be affected by a raised platform. ADA and AAB do not require the lower rail, but it is recommended by the MBTA.

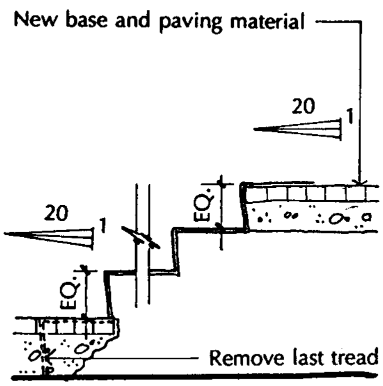


Fig. 2-57
Stair Detail at Raised Platform

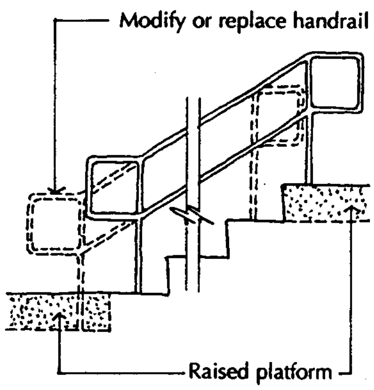


Fig. 2-58
Handrail Modification at Raised Platform

Enclosed or Covered Stairs

Enclosed or Covered Stairs

Since a stair is not part of an accessible route, there are no access requirements that would require covering the stair. However, the MBTA's current policy is to enclose or cover all stairs, existing or new. Covered stairs help eliminate snow and water problems at station entrances.

The station architects will have to work with the MBTA to determine when and if this policy applies to the existing stair entrances that are part of the accessibility project. It is also unclear as to the extent of enclosure that the MBTA would require:

1. enclosed on three sides, with overhang and grate, or
2. enclosed on all four sides with doors.

It is important to note that in many of the historic contexts of Back Bay, which the Green Line traverses, a stair headhouse, like an elevator headhouse, would present complicated and, in many cases, unwanted conflicts with existing historic structures and places. Contextual and adjacency constraints especially at the Old South Church, Arlington Street Church, The Shreve Crump & Low Building, The Public Garden, Copley Square, and where retail establishments are located behind, are important factors in determining which stairs to cover and how these headhouses would look. Location options for elevator headhouses have been eliminated because of such adjacencies. The location of stair headhouse should receive the same type of scrutiny.

In order to mitigate a potentially conflicting structure at street level, the following options should be reviewed:

- keeping certain stairs uncovered while attempting to solve weather problems through maintenance, drainage, or snow melting devices;
- combining stair headhouses with elevator headhouses;
- extending canopies off existing buildings, where possible.

Exterior Open Stairs

Exterior Open Stairs

Many of the existing open stairs into the subway stations have parapet walls. If it is determined that these stairs are to remain uncovered it may be possible to modify or eliminate those walls as part of the accessibility project.

Barriers required around open stairs should be designed to be as transparent as possible in order to intrude as little as possible on the existing urban fabric. This is especially important when the stair opening exists in an historic context or on a tight sidewalk. This can be achieved by an open rail.

Figs. 2-59 and ***2-60*** illustrate a stair with a railing in front of the Heritage and a stair with a parapet wall in front of the Shreve Crump & Low Building.

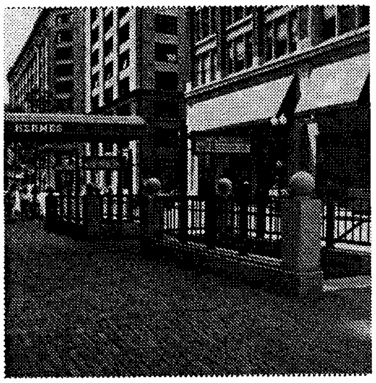


Fig. 2-59
Stair with a Railing

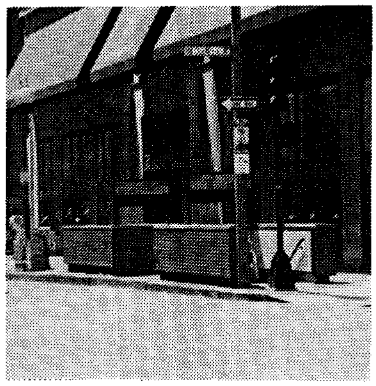


Fig. 2-60
Stair with a Parapet Wall

Fig. 2-61 shows the design goal for open stairs, where the parapet walls can be removed.

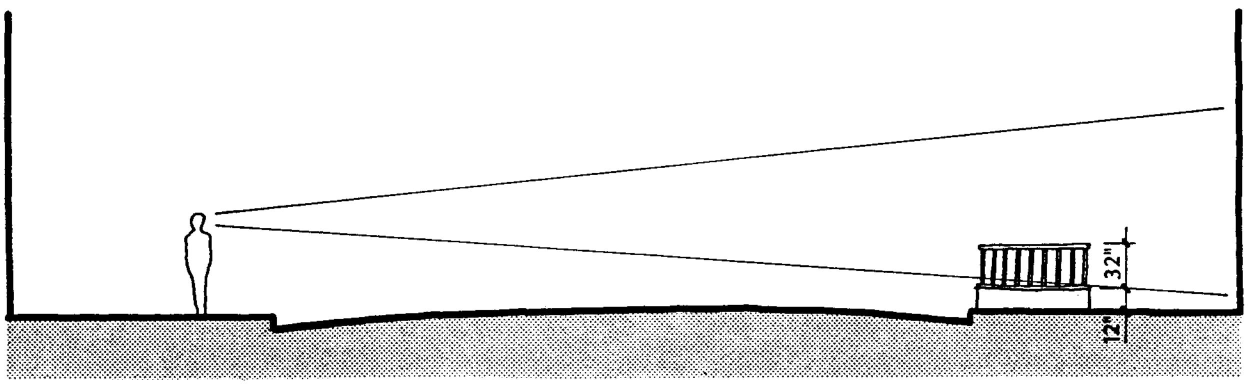


Fig. 2-61
Open Stairs

2.2.8 Ramps

Ramps other than curb ramps may be required adjacent to the stairs in some of the surface stations. Existing ramps should be reviewed for compliance with current access requirements.

Slope/Width

Slope/Width

Refer to the current *MBTA Guide to Access* for detailed requirements for slopes, widths, landings, surfaces and handrails. Some important criteria are summarized below.

In general, the MBTA requires the slope of a ramp to be no steeper than 1:12.5, 48" clear width, with railings on both sides. The length of the ramp is not to exceed 30' with 60" minimum landings at the base of each run.

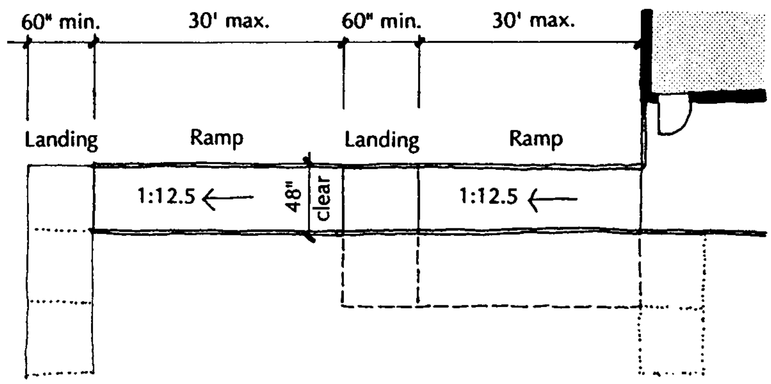


Fig. 2-62
Ramp and Landing

For ramps with a slope of less than 1:16, a 40' run is permitted.

Handrails

Handrails

Handrails along ramps shall be designed as per *MBTA Guide to Access*. Since they are in exterior locations, they should be made out of stainless steel. Galvanized steel will eventually rust and is not preferred.

Covered Ramps

Covered Ramps

Current MBTA access guidelines state that if a ramp serves as the accessible entrance to a station it will need to be covered. Several stations on the Riverside Line fall into this category. See ***Fig. 2-63.***

Whenever possible, the ramp covering should be designed together with the adjacent stair. If the ramp is located elsewhere, the ramp headhouse and other structures should compliment each other.

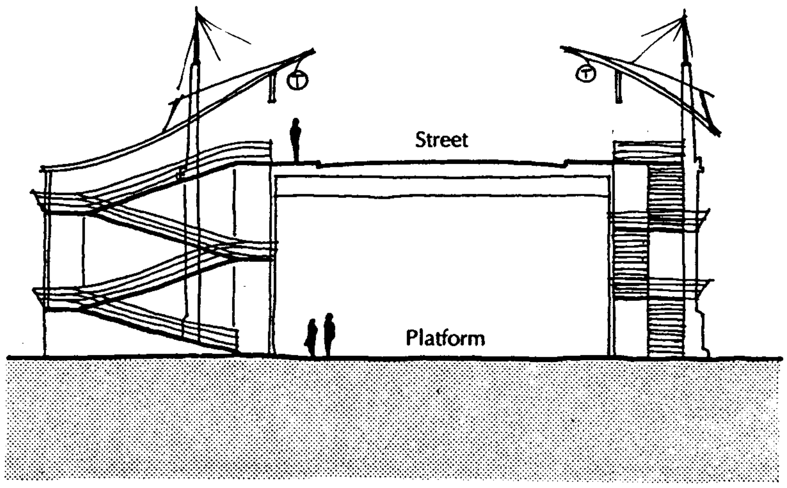


Fig. 2-63
Ramp and Stair Headhouses

2.3 Fare Collection

The MBTA is currently planning a new automated fare collection system throughout its Rapid Transit System. The proposed system will eliminate the direct transfer of cash or tokens at stations and on trains and will instead incorporate ticket vending machines which will allow riders to purchase both passes and stored value cards which resemble the currently used MBTA passes.

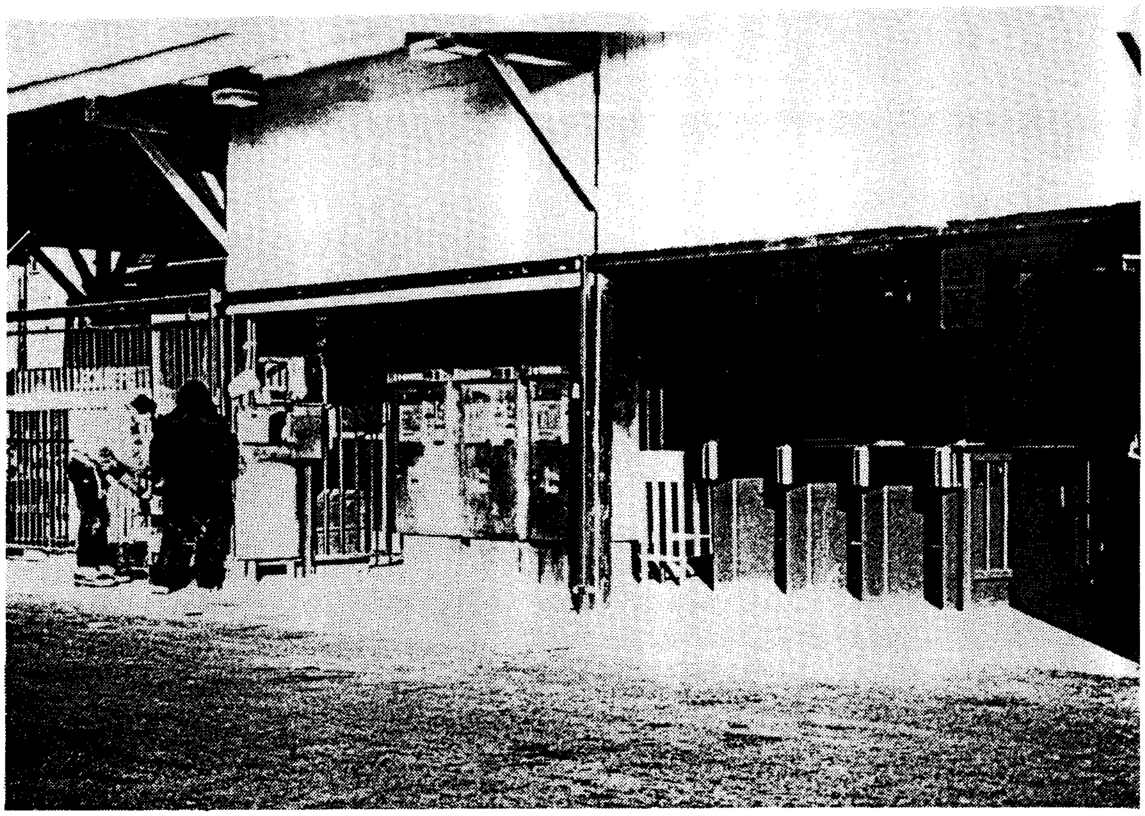


Fig. 2-64
Existing Fare Collection System

2.3.1 Existing Fare Collection System

The existing fare collection system on the Green Line is fairly complex. At subway stations, riders pay fares (tokens or pass cards) prior to boarding trains, typically passing through turnstiles. This enables the trains to open all doors for boarding. At the surface stations, where providing a manned fare collection area is usually not practical, fares are paid while boarding the train. Since fare collection can only occur at the front door of each Light Rail Vehicle where the operator is, vehicles cannot always open all of the doors at each stop. A policy decision was made to only collect fares on the inbound direction, enabling all doors to be opened to reduce vehicle dwell time in the outbound direction. On inbound runs, the train opens only the front door.

When the new Low Floor Vehicles begin to enter service, the existing fare collection system will be problematic. In order to be accessible, the new vehicles will have to open the unmanned middle doors on demand at every station, effectively precluding front door fare payment at surface stations.

2.3.2 Automated Fare Collection

When fully activated, the MBTA's new automated fare system will be a "proof of payment" system. Riders will initially purchase a pass or stored value card worth a set number of fares. Prior to boarding the train, patrons will pass the stored value card through a validating machine which will subtract the fare from the card and give the patron a proof of payment or "receipt" which the rider will be required to present to Authority personnel on the train on request.

Although full implementation will be spread out over several years, the new system will consist of the following: At subway stations or stations which can accommodate turnstiles, new turnstiles will be installed which will read the stored value cards and record the proof of payment magnetically on the card. Stored value card (ticket) vending machines will have to be installed in the station's unpaid area. Fare collection booths will no longer be necessary. Instead, each station will be provided with a customer service agent booth which will provide for information and security only and will not deal directly with fare collection. At surface stations, where turnstiles are not provided, the ticket machines will be supplemented with card validator machines which will also validate stored value cards.

The MBTA is in the process of selecting a manufacturer for the new fare system. Depending on the selection, the exact specifications of the system components may vary considerably. The number of turnstiles, ticket, and validator machines required at each station will, to some degree, depend on the capacity of the specific product. The dimensional parameters of different products also are likely to vary. To facilitate in the planning for the new system, the Authority's Revenue Department has established some general guidelines which will generally be compatible with whichever manufacturer is finally selected.

Both the ticket machines and the validator machines can be assumed to measure 24" wide by 36" deep by 79" high. They will need to be provided with both power and communications connections. The number required will partially be a function of station utilization. The new turnstiles will be dimensionally similar to those existing, however the number required could vary. The existing fare collectors booth will either be modified in place, relocated or replaced entirely with a new customer service agents booth. It will no longer be necessary for the booth to be in line with the turnstiles, however the chosen location should provide maximum visibility for security purposes.

At subway stations, the quantity of fare collection equipment varies considerably, with approximate numbers presented in Appendix 6 of the *Schematic Design Report.* For more detailed information on each key subway station, see Chapter 6 of the *Schematic Design Report.* At each surface station, a minimum of two validators and two ticket machines should be provided, with more provided at busier stations.

At many surface station platforms, the space available for fare collection machines is limited. The locations must not interfere with the deployment and usage of the train access ramps. The machines must be situated on the platforms to minimize obstructions to the path of travel and to avoid long queuing lines which may impede circulation. Ticketing and validating machines should generally be paired up for efficient usage and should be located near the entrances to the platform for convenience. Since many platforms have multiple entrances, the locations should be near the most heavily used entrances. If severe space constraints exist, it may be necessary to locate machines along approaches to the platforms, on sidewalks for example. Unless the Authority chooses to change the existing fare structure, all machines should be located on the inbound platform.

At the subway stations, there is often inadequate space for both turnstiles and ticket machines. Machines should be located so as not to impede circulation. It may be necessary to locate groups of machines on the surface adjacent to the station entrance. At several stations, substantial alterations may be required to provide adequate space.

All fare collection equipment will need to be provided with adequate lighting. Directional and identification signage will also be a critical element.

The new collection system will be activated in several stages. Initially, only validator machines will be provided at the busiest surface stations (see list in Appendix 6 of the *Schematic Design Report*). Ticket vending machines are anticipated to be delivered within two years after the validators. At subway stations, both new turnstiles and vending machines will be installed. The new fare collection system must be fully accessible to persons with disabilities. At least one ticket and validating machine at each station must be accessible. They should be located so as to minimize the path of travel distance. Since machines will most often be approached from the side, center to center clearance should be at least 5'.

2.4 Platforms

Platforms are the primary system-wide element on the Green Line. The existing platforms vary in length and width at both surface and subway stations. Many stations exist with only signage and platforms.

One of the charges given to the station designer is that the route to the station, defined in Chapter 2.2, or platform be made accessible. The second charge is to make the platform accessible. This chapter will address the requirements for making surface and subway station platforms accessible and also address the issue of designing platforms so that they are a consistent identifiable element throughout the system. It is recommended that designers reference Section 2.2, Circulation, and Section 2.7, Lighting, for additional information in designing a station platform.

Platforms exist throughout the Green Line system in an array of finishes and dimensions. Most existing platforms at the surface stations are paved with bituminous concrete and have a painted yellow warning strip at the edge. Subway station platforms have a variety of existing finishes including tile, brick pavers, terrazzo, and broom finish concrete. All of these platforms have the yellow warning strip in various materials.

None of the existing platforms meet current and future ADA/AAB requirements nor the dimensional requirements of the MBTA's No. 8 Low Floor Vehicle. With the exception of Riverside Station in Newton, none of the platforms on the Green Line have the proper tactile warning strip at platform edge.

The new Low Floor Vehicles currently being designed for the MBTA have requirements for a deployable ramp to be used by persons with disabilities entering and exiting the vehicle. This new equipment requires that platforms be 8" from the top of rail. All existing platforms are currently level or slightly above top of rail.

2.4.1 Low Floor Vehicle Description

The new No. 8 cars have three doors on each side. The front door serves the high floor area and the two central doors serve the low floor area. These two central doors, equipped with the deployable ramp described above, will be accessible to people with disabilities. ***Fig. 2-65*** shows the LFV and its main dimensions.

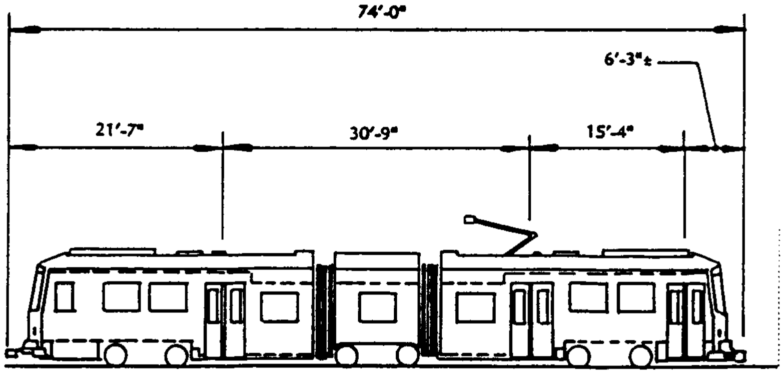


Fig. 2-65
Low Floor Vehicle Diagram

The new No. 8 vehicles use a deployable ramp and low floor technology to allow boarding by people with disabilities. The ramp extends 18" from the car and descends 6" from the floor of the vehicle to the top of platform. The existing platforms at all Green Line stations are too low (approximately at top of rail elevation) and therefore their height will need to be increased to 8" above top of rail in order to allow the new LFV to properly deploy the boarding ramp as previously stated. (See ***Fig. 2-66***).

2.4.2 Proposed Design Parameters

Existing platforms as previously stated must be altered to accommodate the current and future ADA/AAB requirements and new LFV deployable ramps. Along with raising the existing platform, a compliant tactile warning strip at the platform edge is required. The preferred design cross slope of a platform is 1%, however, 2% is the maximum slope for accessible paths of travel. Platforms should be sloped toward the rails where adequate trackbed drainage is provided.

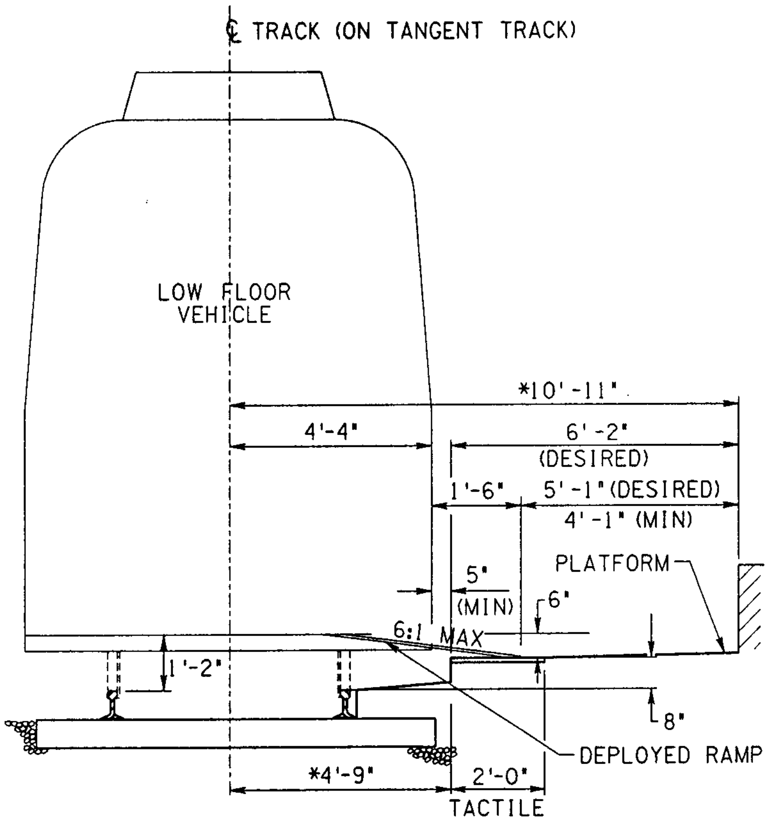


Fig. 2-66
LFV at Raised Platform at Tangent Track

LFV at Raised Platform at tangent track

1. Platform Length (3 car consist)
   * Raised Platform Length
   a. *Design Length = 225'-0"
   b. *Minimum Length = 195'-0"
   c. *Entire Platform Length at Subway Stations

2. Platform Width

   a. Design Width = 10'-11" from the centerline of track to a barrier.
   b. Minimum Width = 9'-11" from the centerline of track to a barrier. However, this will require a variance.
   c. Minimum Clearance to structure = 5'-3" (See ***Fig. 2-67***).

3. Platforms must be raised to 8" from top of rail.

Station designers should also reference Section 2.2, Circulation, and Section 4.1, Civil Engineering, for additional information.

2.4.3 Platform Organization

In addition to designing new platforms to the required length, width,and height, items must be strategically placed on the platform to have a working station. Shelters, signage and benches are but a few of these items. Depending on the width and length of the proposed platform, the placement of such items is critical in their relationship to the No. 8 vehicle's deployable ramp. (See ***Fig. 2-67***).

A complete analysis of platform clear zones necessary for deploying the LFV ramp is presented in Appendix No. 1. Platform elements must be arranged to lie outside the ramp zone as explained in the Appendix and shown in ***Fig. 2-68***.

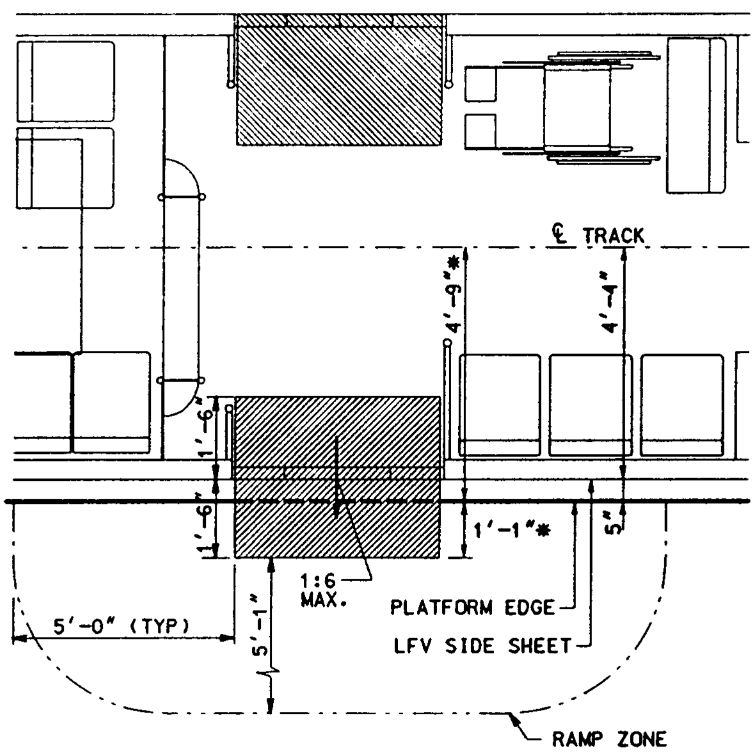


Fig. 2-67
LFV Ramp Zone at Tangent Track

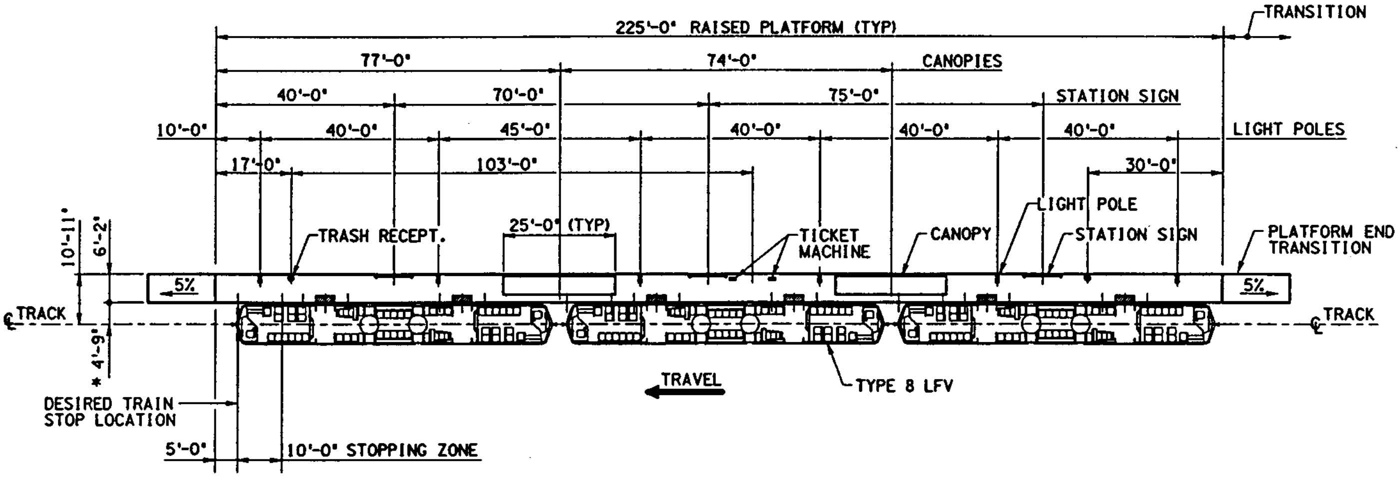


Fig. 2-68
Platform Elements Locations

Note: One or both of the 5% ramps can fall within the 225'-0" platform length when space is limited. Catenary support poles may occur on the platform.

2.4.4 Platform Construction

Both surface and subway stations require accessible raised platforms. These platforms must be compatible with all operating vehicles on the Light Rail System. The major platform construction elements for both surface and subway stations are identified below.

Construction of all new raised platforms at surface stations will require removal of the existing platform. Existing platform materials include bituminous concrete, brick, cement concrete and timber edging.

New raised platforms will be constructed of concrete pavers on a base of cement concrete and compacted gravel. A two-foot wide precast concrete unit will form the edge of raised platform. The tactile warning strip will be fixed to this unit. Concrete pavers on a base of stone will separate the edge of raised platform from the rail. These pavers are sloped at 1 in 12 and should allow for platform drainage. There will be a 6" step from the edge of raised platform to the pavers. The edge will vary in width depending on the degree of track curvature (See Section 3.4, Track Clearances). Platform details

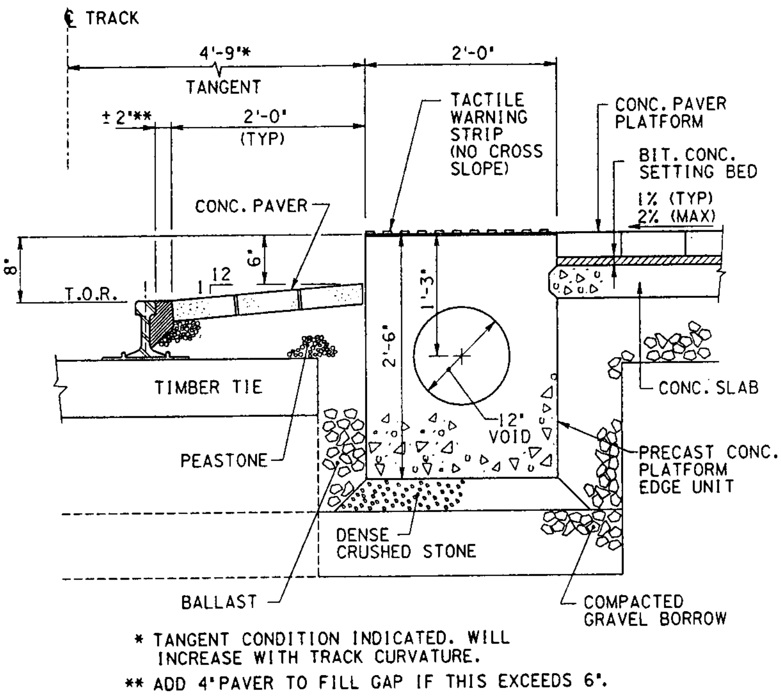


Fig. 2-69
Proposed Surface Platform Edge Details

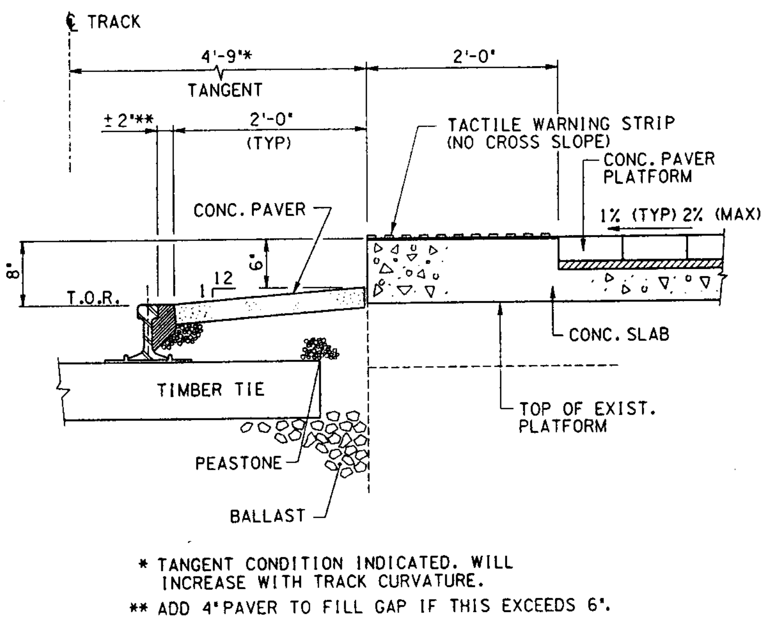


Fig. 2-70
Proposed Subway Platform Edge Details

of surface and subway stations are shown in ***Figs. 2-69*** and ***2-70.***

Accessible sloped paths must be provided at both ends of a platform. Ramps should not exceed a slope of 5%. For slopes greater than 5% handrails must be provided. For stations located in a median reservation the ends of platform are accessed by crosswalks and curb ramps. Curb ramps will typically be reconstructed as part of platform construction. Adjacent grade crossings should extend into the platform area to provide a continuous path of travel between crossings.

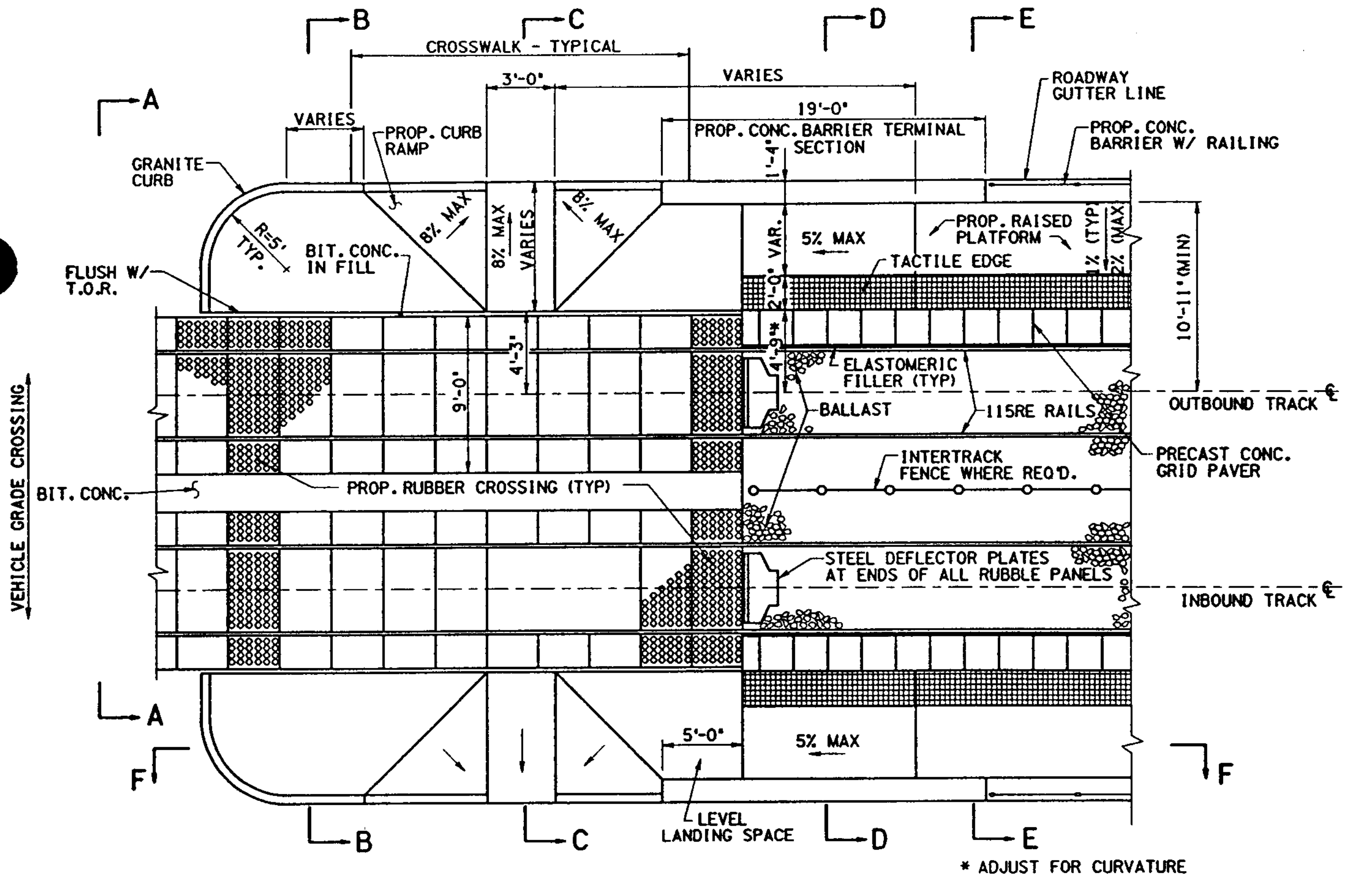


Fig. 2-71

Typical Platform End Plan with Level Landing Space

Note: Catenary support poles and traffic signals may occur within crosswalk and platform area.

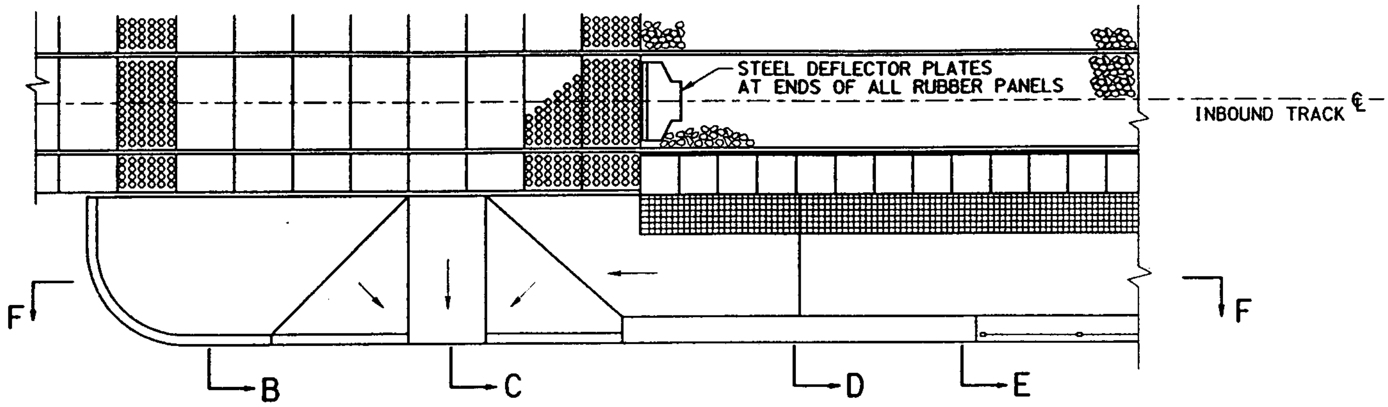


Fig. 2-72 Typical Platform End Plan without Level Landing Space

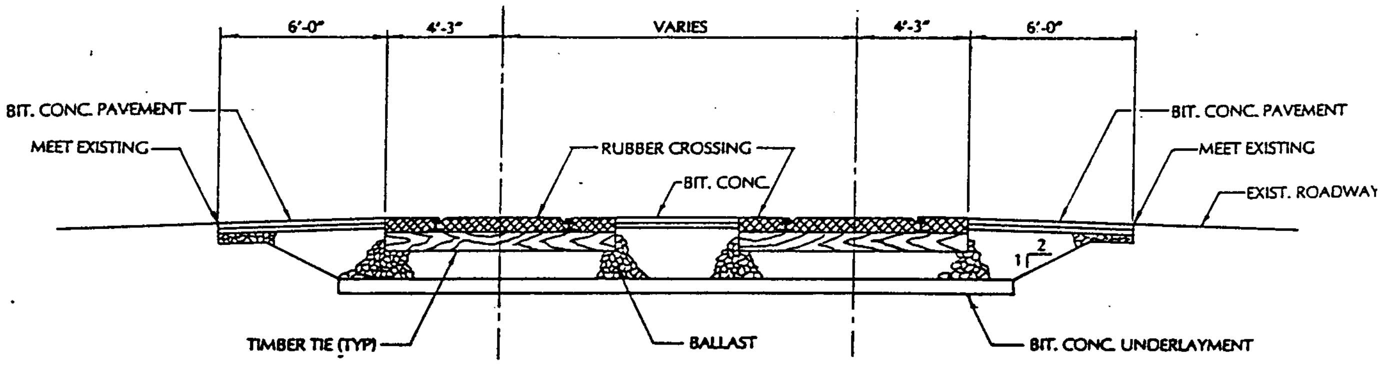


Fig. 2-73 Rubber Grade Crossing Section at Intersection (A)

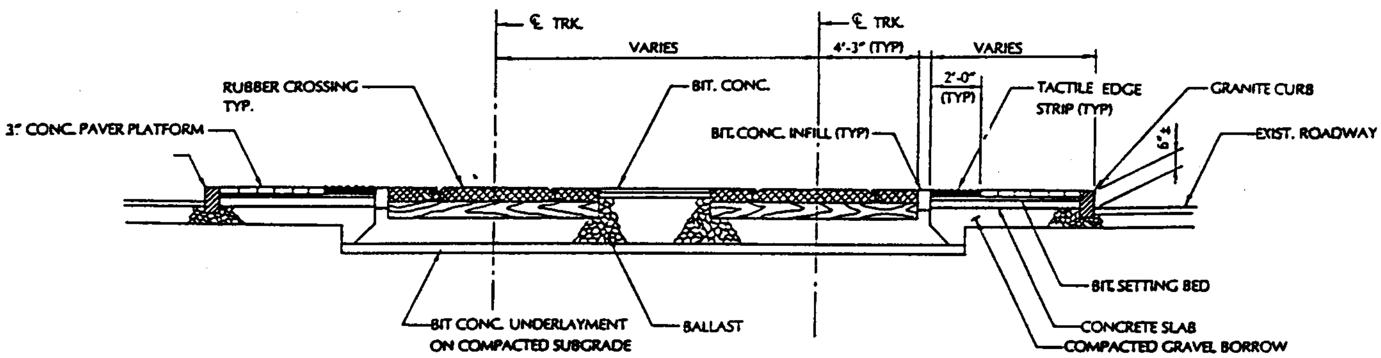


Fig. 2-74 Rubber Grade Section at Platform Area (B)

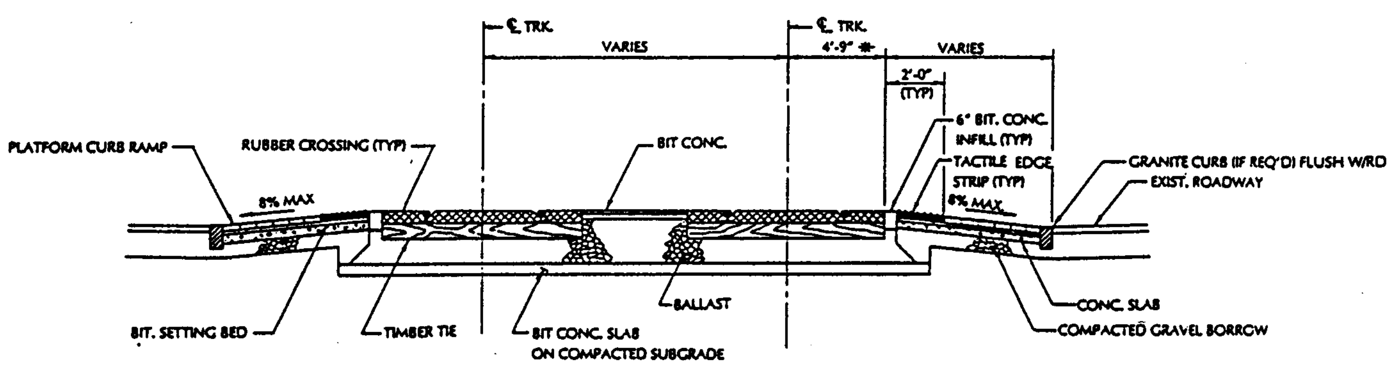


Fig. 2-75 Rubber Grade Crossing Section at Platform Curb Ramp (C)

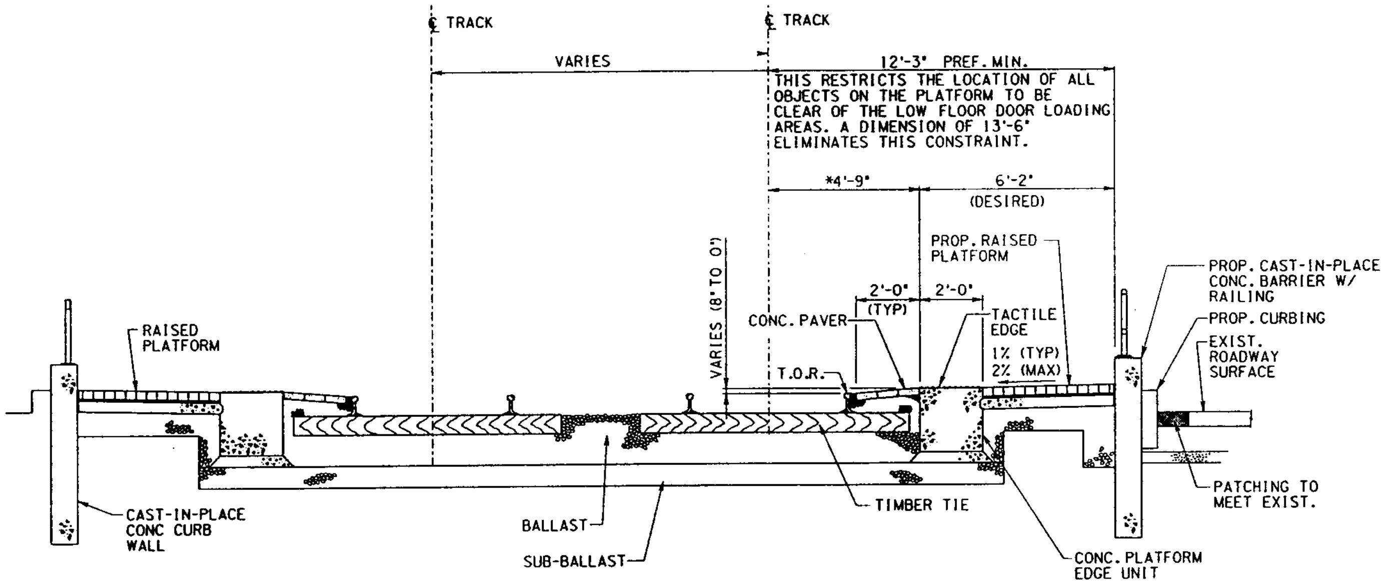


Fig. 2-76 Typical Section at Platform Transition Area **(D)**

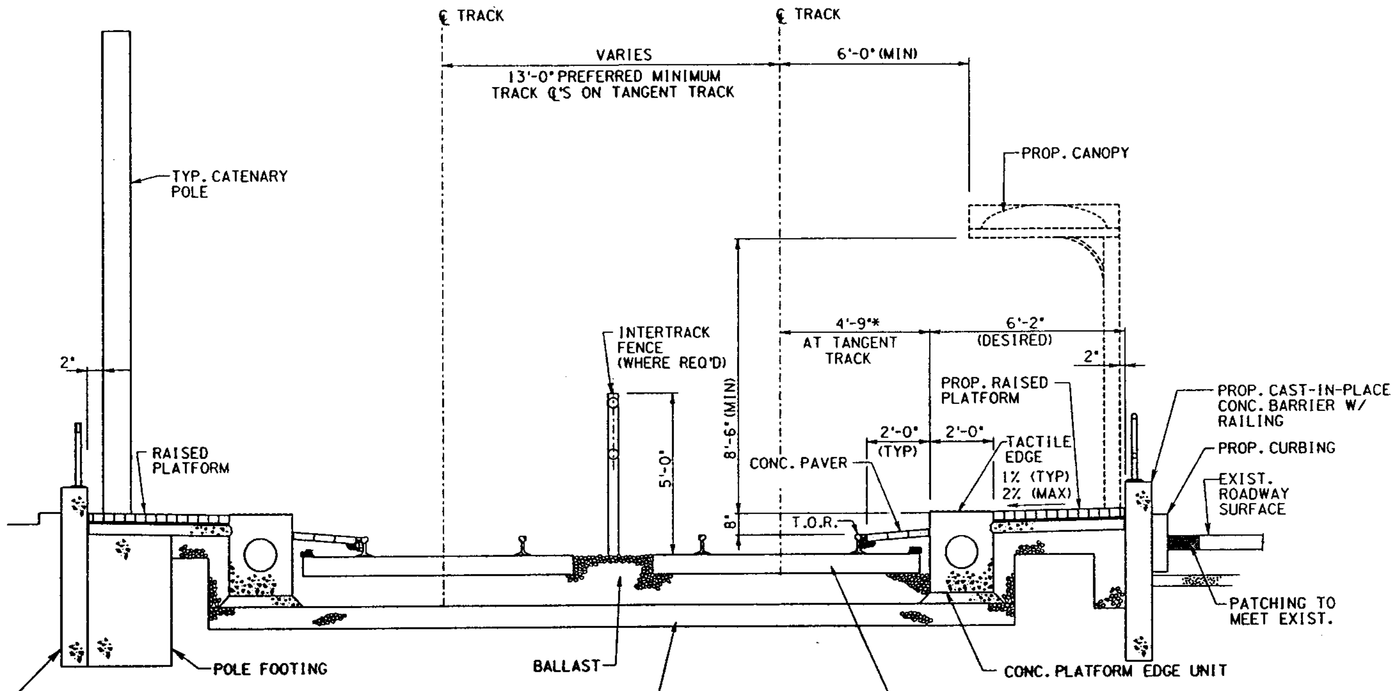


Fig. 2-77 Typical Section **(E)**

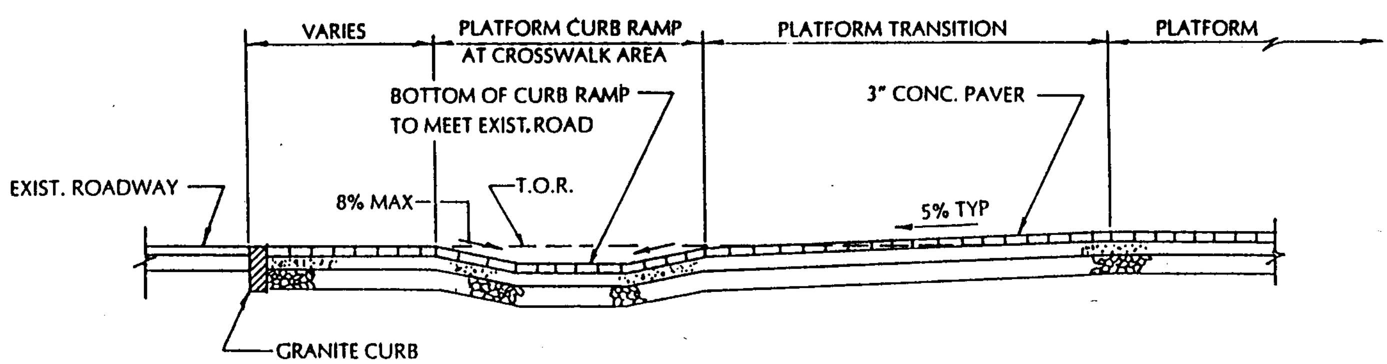


Fig. 2-78 Typical Longitudinal Platform End/Section at Crossing Area **(F)**

Where space permits, a level landing should be provided between the curb ramp and the platform ramp as shown in ***Fig. 2-71***. Where adequate space to provide a 225′ platform does not exist the level landing can be removed as shown in ***Fig. 2-72.*** ***Figs. 2-73 through 2-78*** represent sections through the platform and crossing area.

Catenary support poles and traffic signals may occur within the crosswalk and platform area, however these should be located so as not to block the accessible path of travel.

For stations involving platform widening, new concrete barriers or retaining walls may be required. Platform widening next to adjacent roadways will require a new barrier such as that shown in ***Fig. 2-79.*** Platform widening next to the adjacent off-street parking may require construction of a low retaining wall such as that shown in ***Fig. 2-80.*** .Refer to Section 4.2 for information regarding structural design of platform elements.

The existing platforms in subways will remain in place, excluding any tile surfaces, with the new raised platforms constructed on top. The existing platform edging must be removed up to approximately 6'-5" from the centerline of track.

New raised platforms in subway stations will be constructed on the existing platform surface. A finished surface on a concrete slab will be used to raise the platform. The tactile warning strip will be fixed to the slab. Concrete pavers on a base of stone will separate the edge of raised platform from the rail. Similar to surface stations, the width of this edge will vary in width depending on the degree of track curvature (See Section 3.5). These platform details are shown in ***Fig. 3-5.***

All objects on the platform, including but not limited to, catenary support poles, shelter supports, sign frames, and fare machines should be held "tight" to the back edge of the platform with a typical clearance of 2".

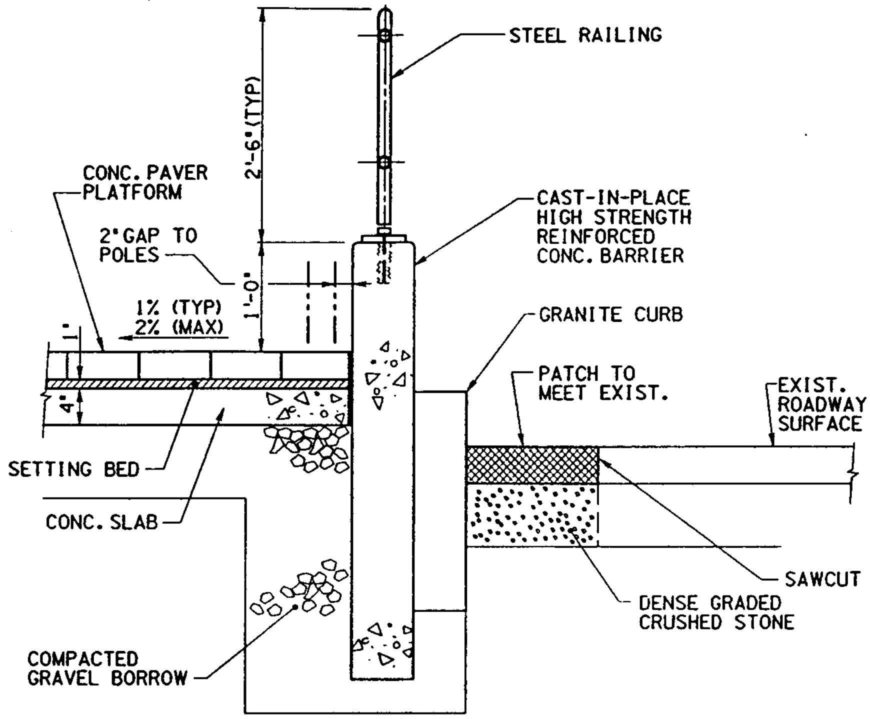


Fig. 2-79 *Proposed Concrete Barrier Detail*

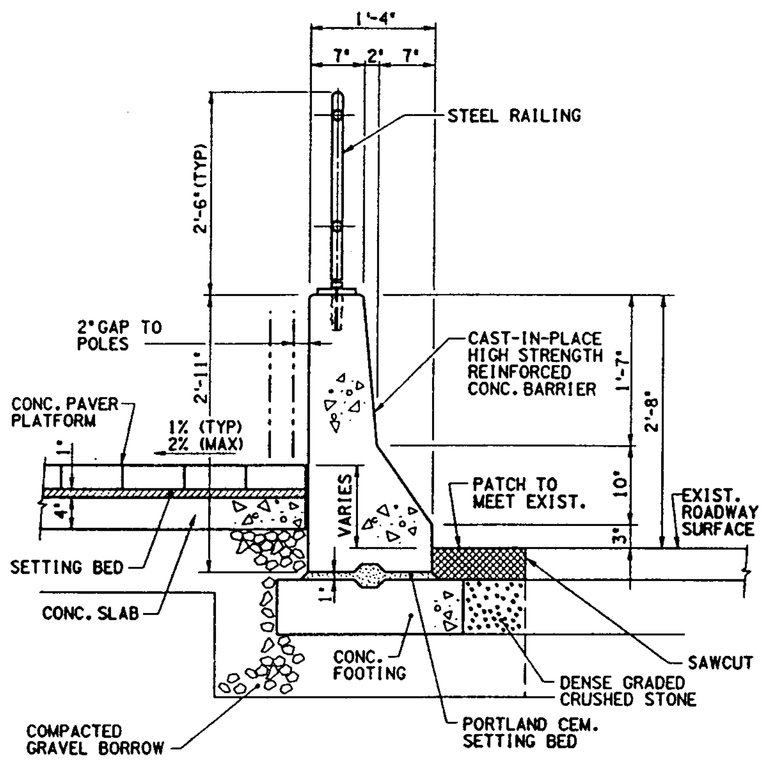


Fig. 2-80 *Possible Alternate Concrete Barrier Detail*

2.4.5 Paving Materials

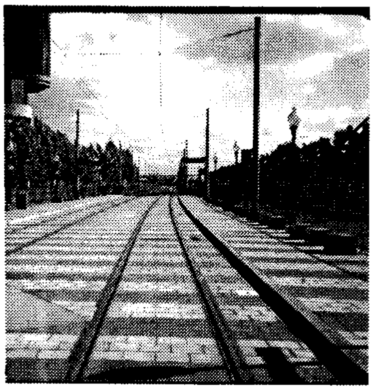


Fig. 2-81
Example of Transit Paving

Existing platforms must be raised to 8" above top of rail (approximately 6″ to 8″) in order to accommodate the new LFV deployable ramps. Along with the raising of the existing platforms, a compliant tactile warning strip at the platform edge shall be added. In addition, the area between the tactile warning strip and the first track will always be paved.

The finished surface of these newly raised platforms will be a unit paver or tile. The surface shall be durable and non-slip. Paving materials or unit pavers shall be set to create even surfaces with narrow joints and flush edges.

Subway Stations

Subway Stations

The paving material used at the new raised platforms in subway stations shall be site specific, tying into the existing adjacent materials and contexts. The paving material shall be carried into the paid or unpaid lobbies if they are contiguous.

Any existing tile or other paving material shall be removed prior to adding a new concrete base slab. The new unit paving material shall be set on the raised concrete slab as required. See ***Fig. 2-82***. While raising the platform the station designer should take the opportunity to bury any new conduits into the base slab.

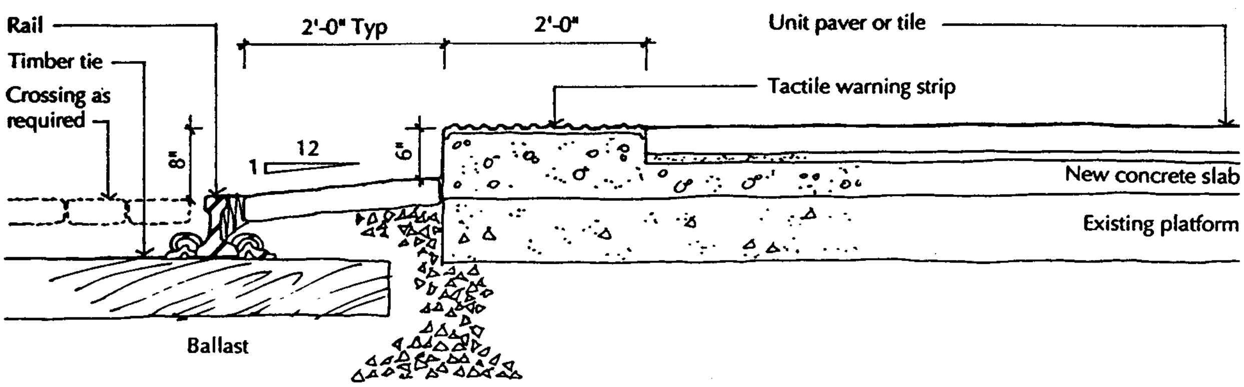


Fig. 2-82
Detail at Subway Station Platform

Surface Stations

Surface Stations

All surface station platforms within each line shall be designed in a system-wide fashion so that they present a consistent identifiable image throughout the line. The paving material shall be a precast unit paver, with sizes approved by the MBTA. Bituminous concrete pavers, although not preferred, may be used in certain locations. The pavers shall be standard colors. See ***Figs. 2-86 through 2-89*** for examples of platform patterns.

The existing platform will be removed and replaced as shown in ***Fig. 2-83*** or ***2-84***. The existing timber strip, adjacent to the rail, will be removed and replaced with concrete pavers.These pavers shall be the same system-wide. Their color should blend in with the tone of the rail bed so the yellow tactile warning strip is perceived as the edge of the platform.

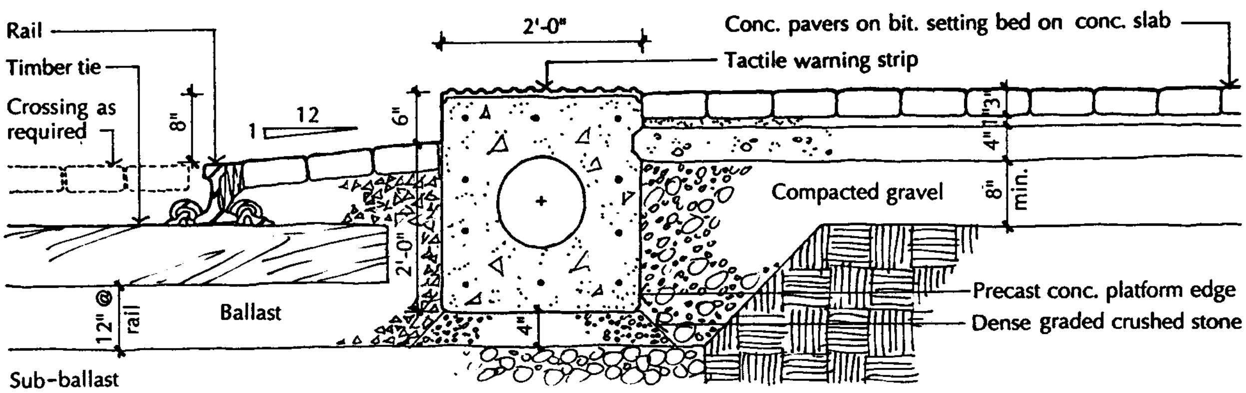


Fig. 2-83
Detail at Surface Station Platform

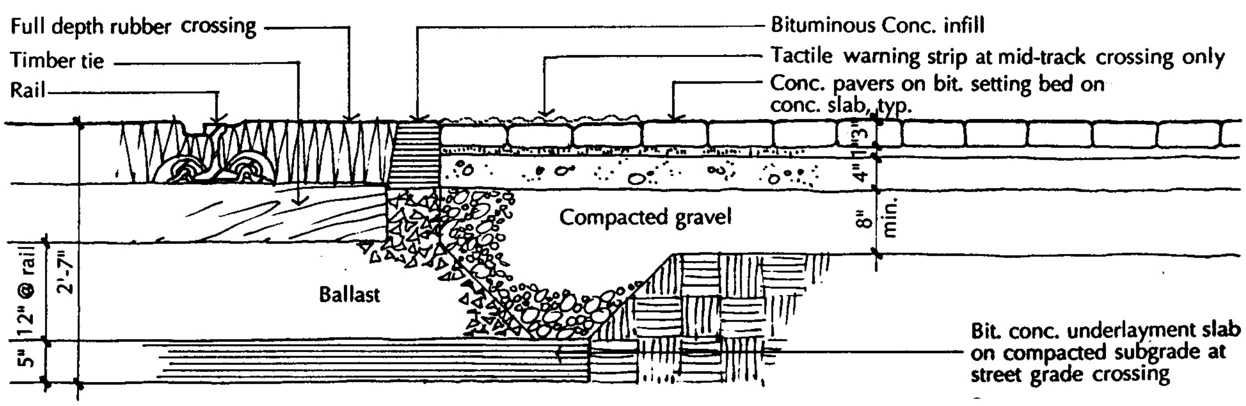


Fig. 2-84
Detail at Surface Station Platform Crossing

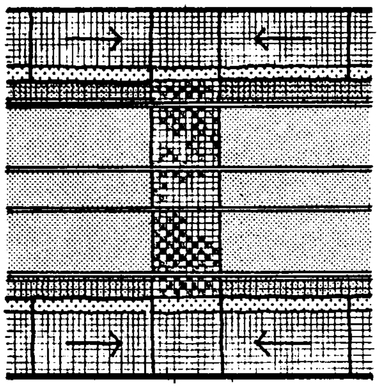


Fig. 2-85
Paved Pedestrian Mid-track Crossing

Where mid-track pedestrian crossings are paved, the pavers adjacent to the rail shall be stopped, and the platform paving continue across. See ***Fig. 2-85***. Although similar materials, the crossing should be treated in a different pattern than the platform in order to differentiate where people cross and where people wait for the train. The tactile warning strip shall continue at these mid-track crossings.

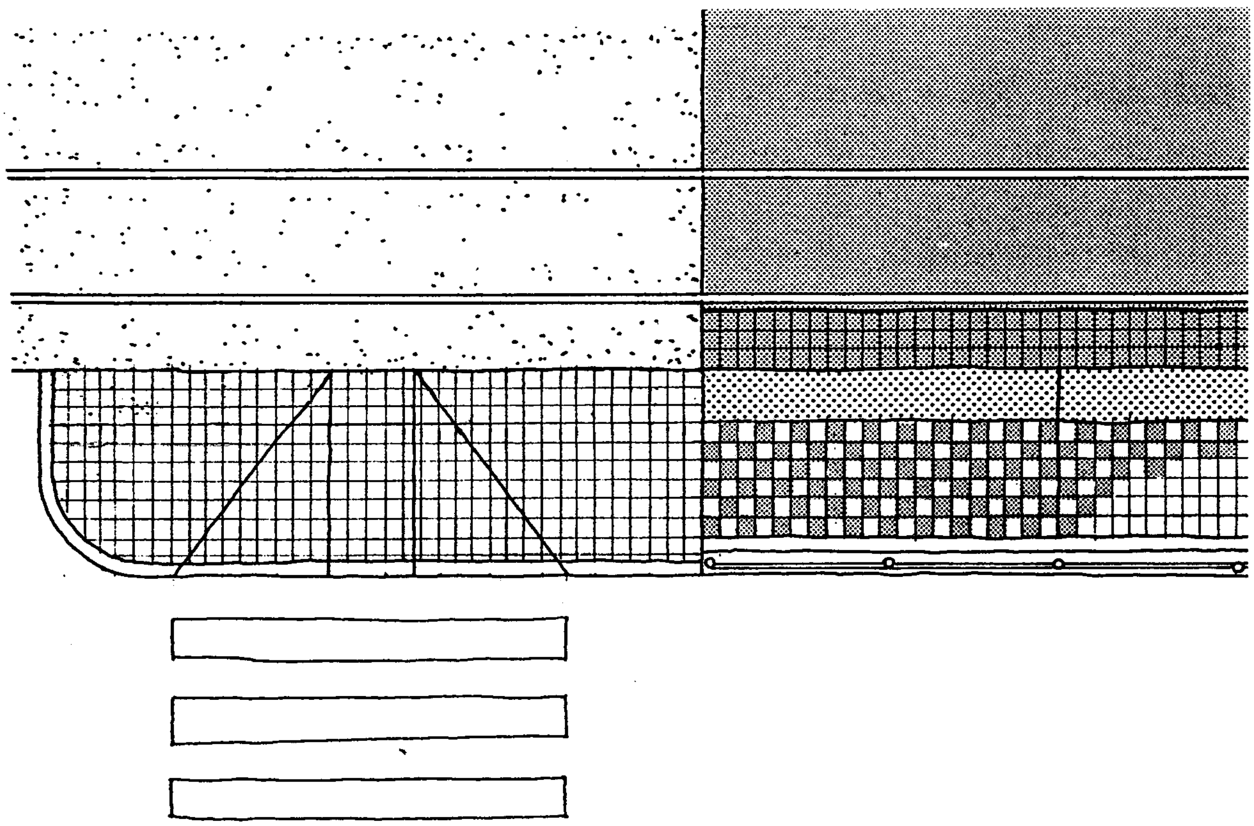


Fig. 2-86
Possible Paving Pattern at Narrow Platform, Alternative #1

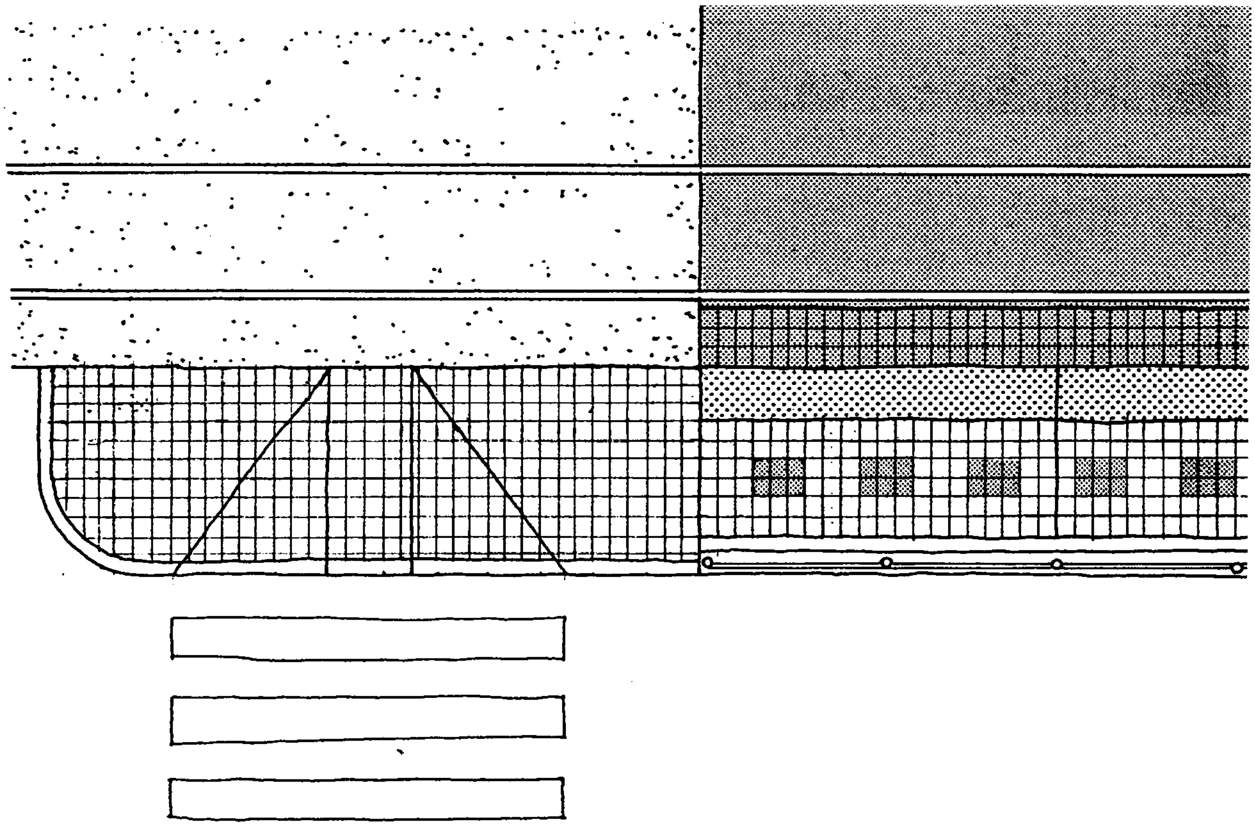


Fig. 2-87
Possible Paving Pattern at Narrow Platform, Alternative #2

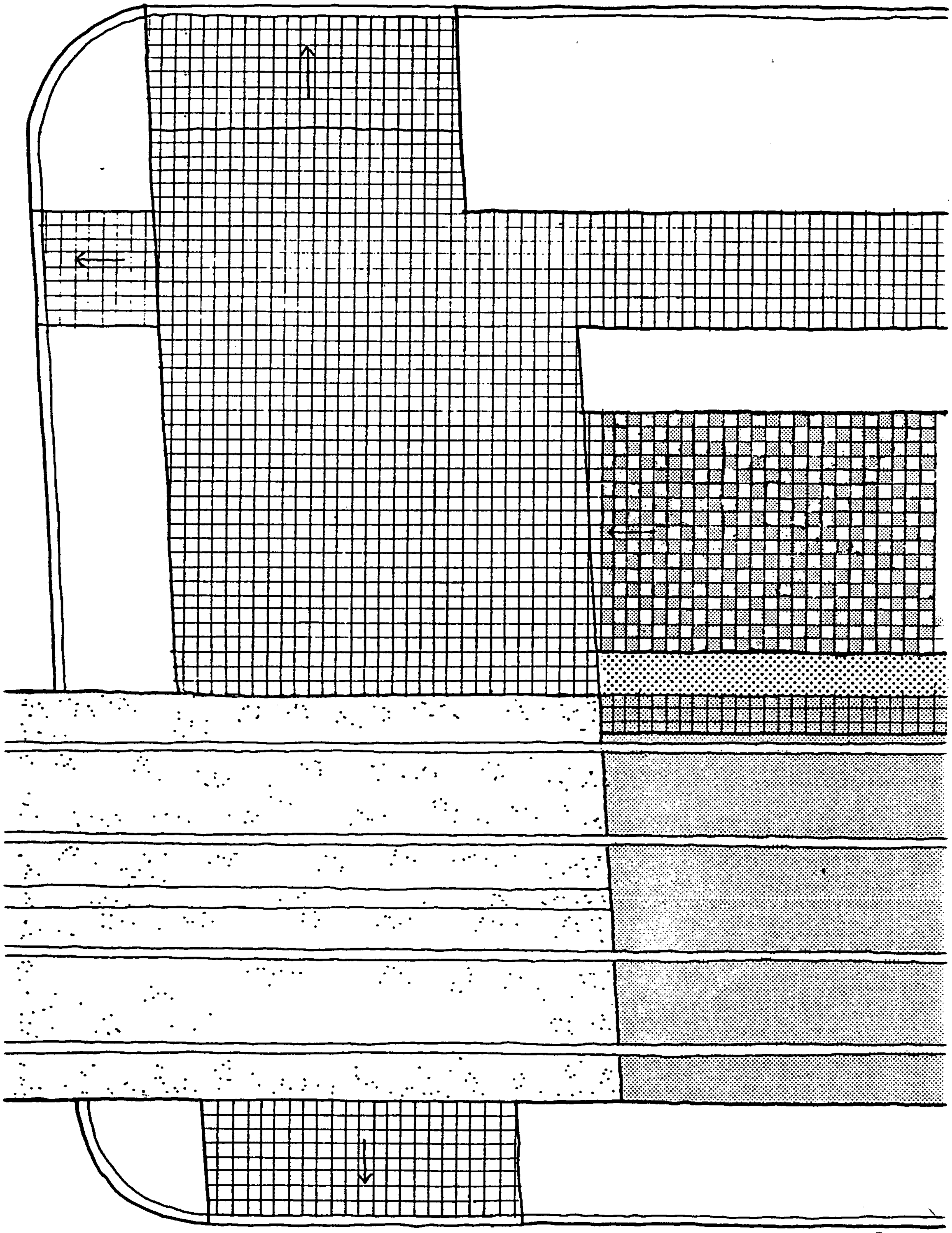


Fig. 2-88
Possible Paving Pattern at Wide Platform, Alternative #1

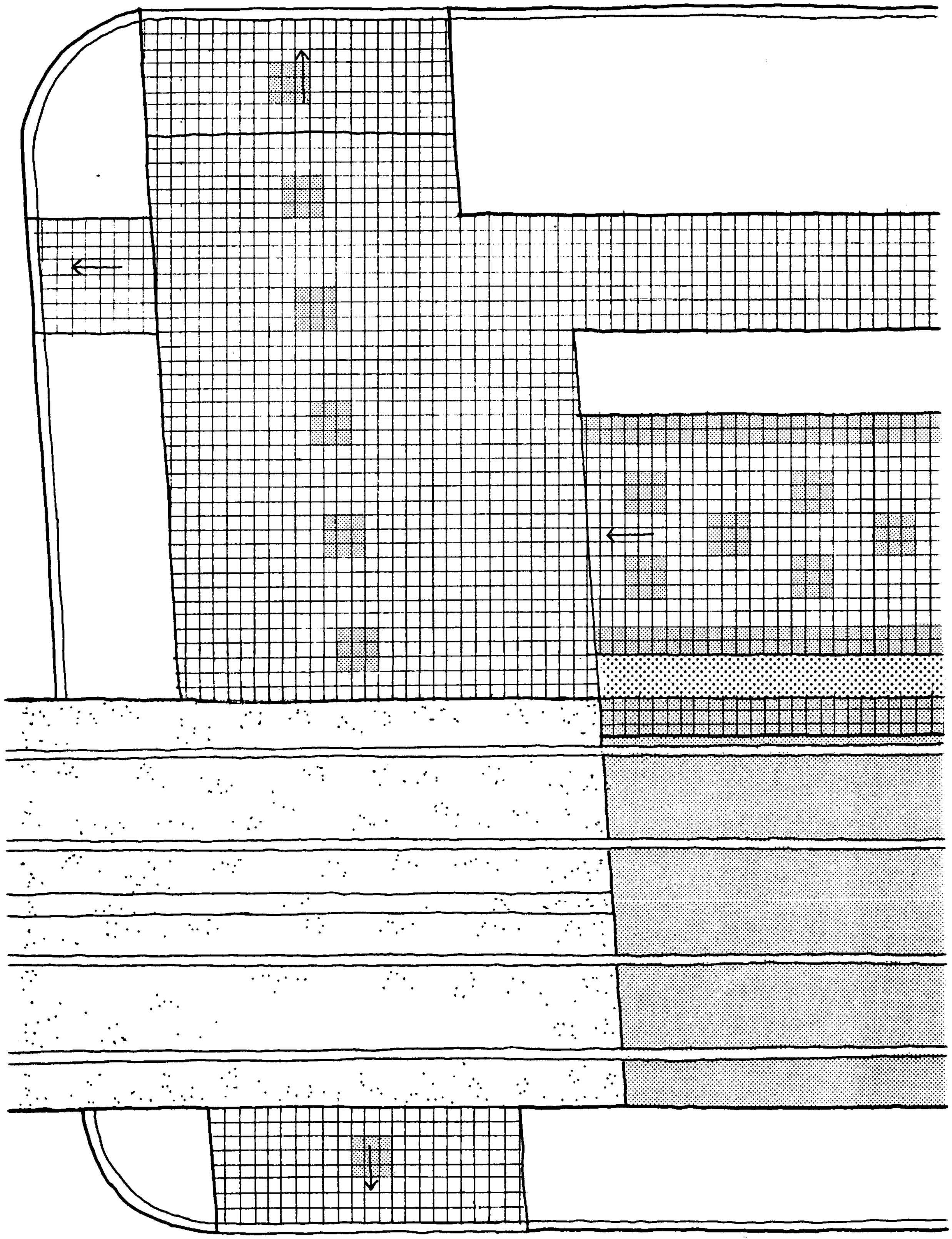


Fig. 2-89
Possible Paving Pattern at Wide Platform, Alternative #2

2.6 Furnishings

The MBTA provides site furnishings to enhance user comfort and to meet accessibility requirements. Consistency in the design of most of these elements will present a unified appearance that will help orient users of the rail system and reinforce the overall Green Line identity. At most surface stations, new site furnishings will be installed. Existing furnishings could be reused at subway stations.

Site furnishings discussed here are: benches, trash receptacles, sand storage boxes, bike racks, information panels, and newspaper vending boxes. Artwork is also discussed in this chapter. Please refer to Section 2.8 for canopies and shelters, Section 2.11 for bollards, Section 2.9 for telephones, Section 2.3 for Fare Vending and Validation.

2.6.1 Benches

Benches provide places for people to sit, to rest, and to put heavy packages. Because benches are such a prominent part of the atmosphere of the site, their location must be carefully chosen. Although site specific, bench location should be as near to the waiting area as feasible, outside, but next to the "continuous passage," and be protected from the elements. Seating is recommended near the top of stairs and ramp, to provide a place to rest after a particularly long ascent. There should be seating in both the paid and unpaid areas of subway stations, and in plaza areas of larger above-grade stations.

On each platform and within the station plaza, there shall be seating at intervals not to exceed 250′. The Draft Mass. Architectural Access Board recommends seating at intervals of 200′. Consult with the Authority, prior to spacing benches, for clarification on this issue.

In subway stations where benches are located at raised floor locations, benches must be removed, and reattached at the appropriate height. It is recommended that such benches be refinished. In addition, armrests should be added as required.

Certain surface station platforms are too narrow to allow for any bench without violating the MBTA's minimum clear space from the platform edge to the nearest obstruction. Other platforms are just wide enough for fixed benches, and still others have room to spare. Because of the variety of platform size and layout, three bench designs have been selected which meet the objectives stated above. Each station designer may use as many of the three bench designs as are appropriate for that particular site.

Regardless of which bench design is chosen, the Federal Architectural and Transportation Barriers Compliance Board recommends that at least half of the fixed benches at each site have a high back and armrests. This design facilitates sitting and rising for people with limited strength and flexibility, and provides a backrest for comfort. The height of the seat varies from 18" to 22", the depth varies from 12" minimum to 18" maximum. Benches shall be sloped to drain from front to back as sloping avoids puddling at the front of the bench. There should be a minimum 3" heel space for ease of rising from a seated position. A 30" by 48" clear ground space for a wheelchair must be provided at one end of at least one bench on each platform or location. This location must be protected from the weather.

Proposed Bench Alternative 'A'

Bench Alternative 'A' Proposed

Bench Alternative 'A', ***Figs. 2-101*** and ***2-103*** consists of the current standard MBTA wooden bench, attached to a wall or supported by posts, and modified to include armrests which are required on at least half of the fixed benches at each platform. The armrests may be constructed of the same material as the bench seat, or of a suitable alternative. Currently,

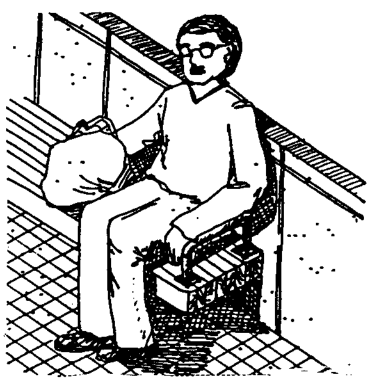


Fig. 2-101
Bench Design Alternative 'A'

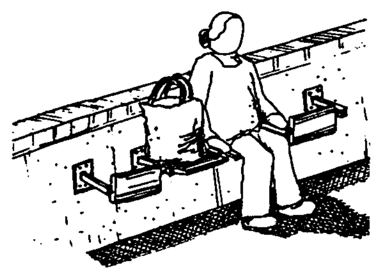


Fig. 2-102
Bench Design Alternative 'B'

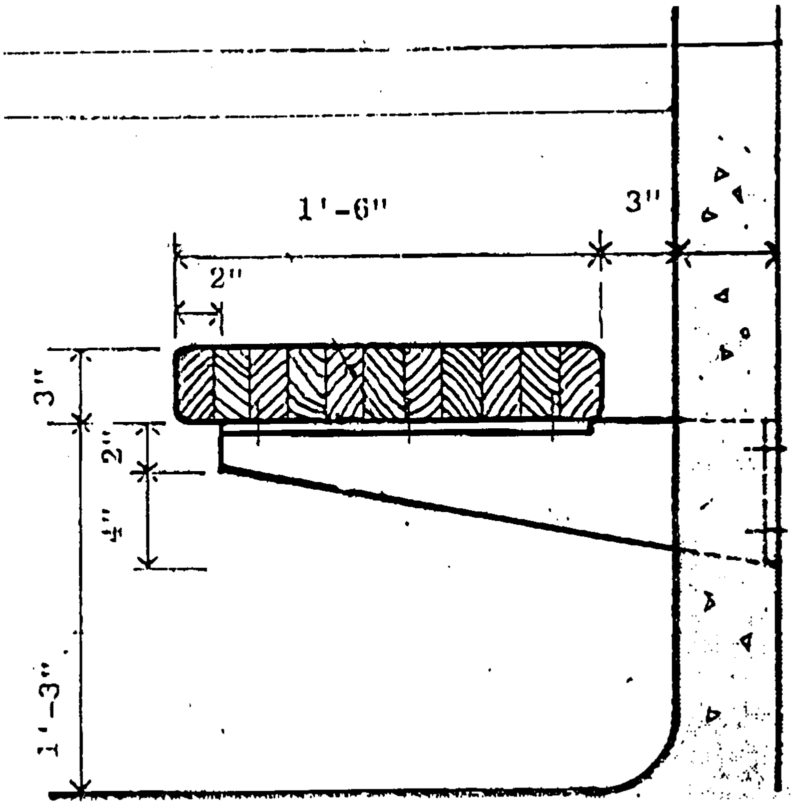


Fig. 2-103
Bench Design Alternative 'A', Wall Supported

the MBTA manufactures and maintains these benches (without armrests) for their own use.

Proposed Bench Alternative 'B'

Bench Alternative 'B' Proposed

Bench Alternative 'B', ***Fig. 2-102,*** is a fold down bench and could be installed at narrow platforms which have limited opportunity for seating because of the minimum clear platform width requirement. The design of this bench allows it to be attached to a concrete wall or shelter or supported by posts to the floor and to fold down when in use and up when not in use. Fold down benches would be located inside platform canopies, shelters or on the open platforms. The bench currently being studied by the MBTA is constructed of molded polypropylene with a baked polyester finish. An alternative to this fold down bench, a folding bench with armrests is also being researched by the Authority.

Proposed Bench Alternative 'C'

Bench Alternative 'C' Proposed

The third bench alternative, ***Figs. 2-104*** and ***2-105,*** should be installed only at stations which have enough space to accommodate them at the plaza or waiting areas. Bench Alternative 'C' is an ornamental cast iron and wood slat type bench. The seat should be made of a hardwood which will weather naturally and be vandal resistant.

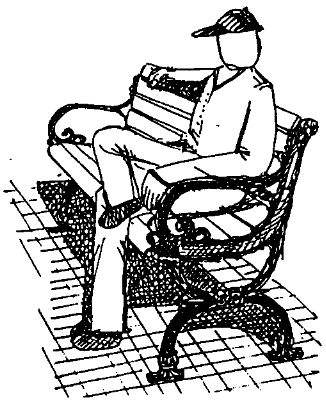


Fig. 2-104
Bench Design Alternative 'C'

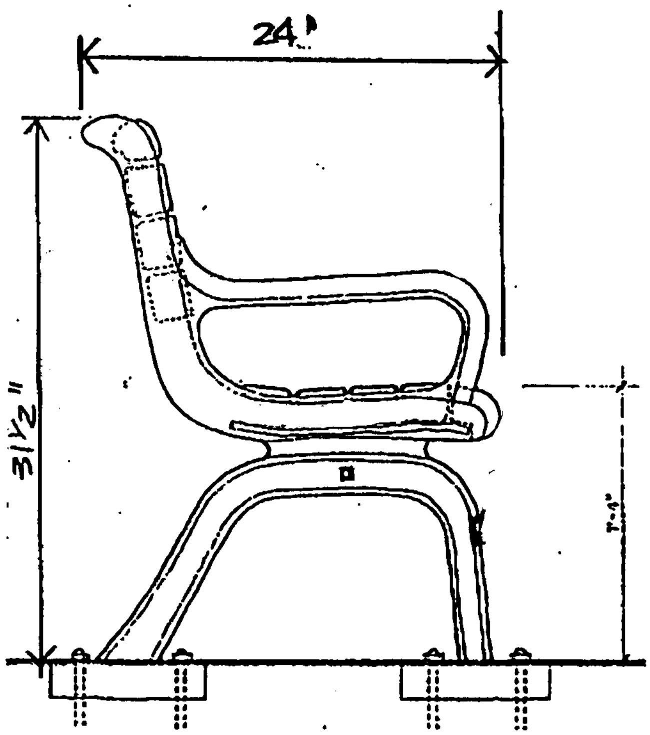


Fig. 2-105
Bench Design Alternative 'C'

This ornamental bench meets all the requirements for accessibility and adds an enormous amount of character and integrity to a site. This bench should be used wherever possible in order to reinforce the station identity.

2.6.2 Trash Receptacles

A station's identity can be highly influenced by its apparent tidiness and cleanliness. The number, design, and location of trash receptacles is important for the safety and attractiveness of the station. Trash receptacles should complement the design of the other site furnishing elements. Currently, most stations are using 33 gallon plastic cylinders or 50 gallon drums as trash receptacles (***Fig. 2-106***).

Fig. 2-106
Existing Trash Barrel

Location

Location

Generally, trash receptacles should be located outside, but adjacent to the path of travel, near the platform entrances, canopies and anywhere appropriate according to need. There should be a minimum of one trash receptacle per platform and enough receptacles to prevent overflowing between scheduled maintenance/ trash removal.

Design Guidelines

Design Criteria

It is recommended that one style of trash receptacle be used for all Green Line stations to maintain consistency, ease of maintenance and replacement. The recommended trash receptacle is made of steel with an electrostatically powder coated black finish. The 32 gallon high density plastic liner should be black for all stations. The height of the receptacle should be 3 feet maximum to the opening. It must be easily accessible for maintenance and must be vandal resistant. A diagram of a proposed style of trash receptacle is shown in ***Fig. 2-107***. Where feasible, recycling receptacles should also be considered for such items as bottles and cans. The MBTA has included newspaper recycling bins at new or renovated stations. Each receptacle should be of a complementary design with other receptacles and all should be labeled to encourage proper disposal of recycled material.

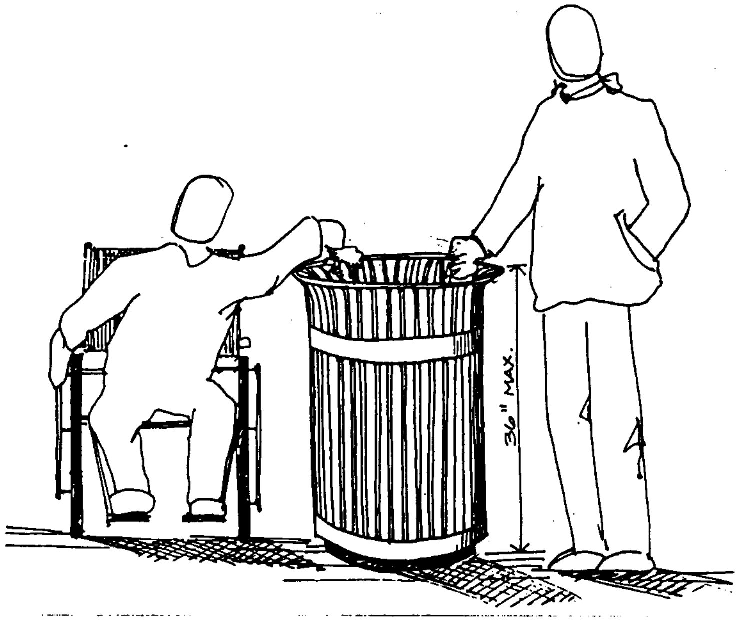


Fig. 2-107
Proposed Trash Receptacle

2.6.3 Sand Storage Bins

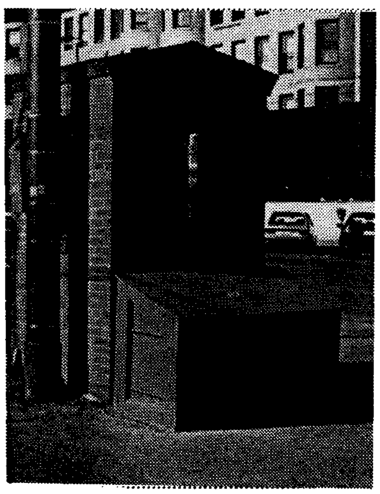


Fig. 2-108
Existing Sand Storage Bin

Because icy and snow–covered pavement can be a hazard in the winter months, all surface stations must have at least one sand storage bin for each station platform. This also includes at least one sand storage bin for each 200 linear feet of bus waiting area. The bins should be located in the areas of the platform not used by passengers, away from entrances and boarding areas. The bins shall be designed to meet MBTA criteria and shall be located outside of the required accessibility route yet easily accessible for maintenance workers. The size of the bin is approximately 2.5' wide and high by 3' long. Currently, the MBTA uses painted wooden boxes which they construct for their own use. In the future, a manufactured fiberglass container will be used for sand storage. All sand storage bins should be black in color.

2.6.4 Bicycle Racks

Bicycle racks shall be provided at surface stations where space allows and shall be located at a point set away from major circulation, but near the station entrance so they are easily observed by station patrons and attendants. Ideally, the bike rack should be located on a 6 foot wide apron of paving which differentiates it from the surrounding paving material.

Each station has specific needs for bike racks. Research should be conducted to assess these needs prior to deciding on the number of stalls that will be provided. Space for future expansion of the bike rack area should be provided, if possible, to avoid haphazard placement as needs become greater. The suggested bike rack is the loop type which is attractive, functional, easily maintained, and comes in a variety of colors. A sketch of the suggested bike rack is shown in ***Fig. 2-109.***

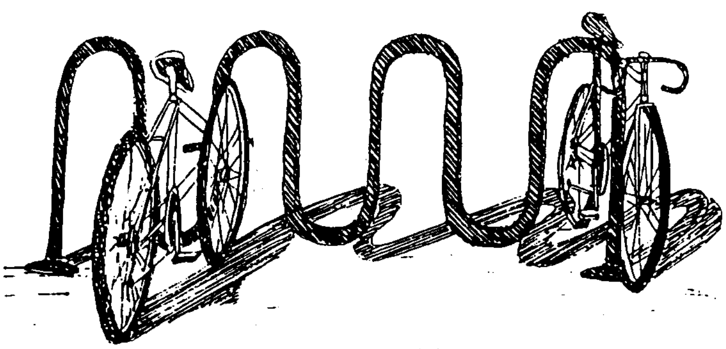


Fig. 2-109
Proposed Bicycle Rack

2.6.5 Artwork

The opportunity exists for the incorporation of artwork into the Green Line system to enhance station identity, help orient users, and provide another unifying element to the entire system. Possible locations for art work include kiosk panels, station walls, banners, freestanding sculpture, and sidewalks. Artwork should be encouraged since it offers an opportunity to make each station special and easily identifiable. This is also an important factor for Green Line users who may have reading or learning impairments and can only identify their location by landmarks or distinguishing features.

2.6.6 Information Panels

Where space permits and the Authority will allow, stations could have an information panel which contains a map, a brief history and points of interest of the local area. A portion of each information panel would be reserved for the community and would provide them with a place to post announcements, local news, and other items of interest. The panels must be similar in design to other signage on the Green Line, and be incorporated into existing signage where possible. In order to allow close access for people in wheelchairs and those with visual impairments, there should be no obstructions in front of the panels and they should be at a height which is easily readable from all eye levels. To accommodate the blind, Braille information should be provided.

The information panels will vary, but in general, should be located where they will be easily seen and read by all users of the station. An example of the information panel is shown in ***Fig 2-110.***

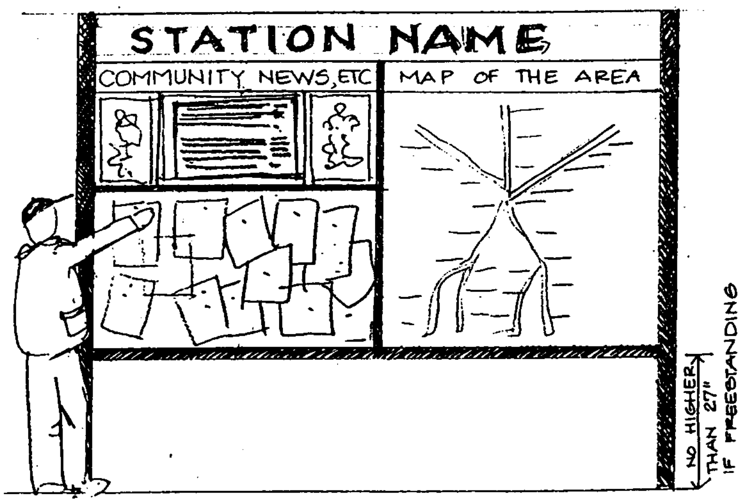


Fig. 2-110
Possible Information Panel

2.6.7 Newspaper Vending Machines

At most stations, existing news vending machines are haphazardly placed and have been vandalized. These conditions can be corrected by designating areas for the installation of news vending machines and the proper method for securing the machines. Location of news machines is station specific, but all machines at each station should be located in one area outside of, but adjacent to pedestrian corridors. At subway stations, machines should be located in the unpaid lobby area and above ground on sidewalks near entrances. There shall be no machines located on the narrow platforms of surface stations and in all cases machines should be located near entries, drop–offs or in the plaza area, if there is one. Machines shall be neatly secured to steel posts which are embedded in the pavement. Vendors will be prohibited from attaching machines to sign posts, tree guards or any other location not specifically designated for news boxes.

Vendors will be notified of where they will be allowed to attach their newspaper machines. Any machines that have been placed outside of the designated area or that obstruct pedestrian circulation in any way, shall be removed by the MBTA. ***Fig. 2-111*** shows the newspaper vending machines attached to posts.

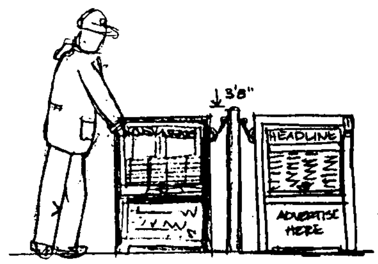


Fig. 2-111
Proposed Newspaper Boxes

2.7 Lighting

This section describes light rail surface and subway station illumination requirements. Station area illumination is critical to the riders comfort and perception of safety. However, high levels of illumination alone are insufficient. Both the quality and quantity of lighting must be considered in the design of lighting for a station. Security, emphasis, visual comfort, compatibility with surrounding uses, efficiency, ease of maintenance and attractiveness should be addressed in the design of each light rail station.

Station Design

Station lighting shall comply with codes and guidelines previously mentioned in this manual.

Station Design

Security

The primary function of lighting is to make the light rail station and site safe and secure for users and visible from surrounding areas.

Security

Emphasis

Highlighting should be used to emphasize hazards, informational elements and major focal and access points. These include:

Emphasis

- Stairs
- Ramps
- Vehicular and pedestrian track crossings
- Platforms
- Pedestrian crosswalks
- Tracks
- Shelters/Canopies
- Elevators
- Head houses
- Signage

Visual Comfort

To insure visual comfort, station and site lighting should:

Visual Comfort

- Provide a level of lighting as required by ADA.
- Provide the appropriate contrast between various station areas and elements..

- Minimize glare. Light sources should not be located within the normal visual angle of pedestrians or drivers.
- Minimize reflected glare from smooth surfaces, such as signs.

Compatibility With Surrounding Uses

Compatibility with Surrounding Uses

Station and site lighting should not interfere with:

- Adjacent residential neighborhoods
- Train operation and signals
- Operation of vehicles off-site

Efficiency

Efficiency

The selection of lighting hardware should be made on the basis of lifetime cost. This includes the cost of purchase, installation, operation, maintenance, and replacement of lamps and standards.

Attractiveness

Attractiveness

Light rail station and site lighting hardware should be:

- Compatible in appearance with the surrounding environment.
- Durable under the following conditions: extreme weather conditions, vandalism, dirt accumulation, and limited maintenance.

2.7.1 Lighting at the Stations

Surface Station Fixtures and Standards

Surface Station Fixtures and Standards

At present light Standards and types vary considerably from station to station. See ***Figs. 2-112*** and ***2-114***. Most of these fixtures will need to be replaced as the platforms are reconstructed. It is recommended that a single standard be specified for each "line". This will ease maintenance and replacement programs, provide continuity within the "line", as well as provide a separate identity from line to line. Station plazas may be appropriate locations for special fixtures that relate to existing adjacent or cross streets. See ***Fig. 2-113*** Where adequate lighting exists from city street lamps, additional platform lighting may not be necessary.

Fig. 2-112
Existing Platform Lighting Fixtures at Coolidge Corner

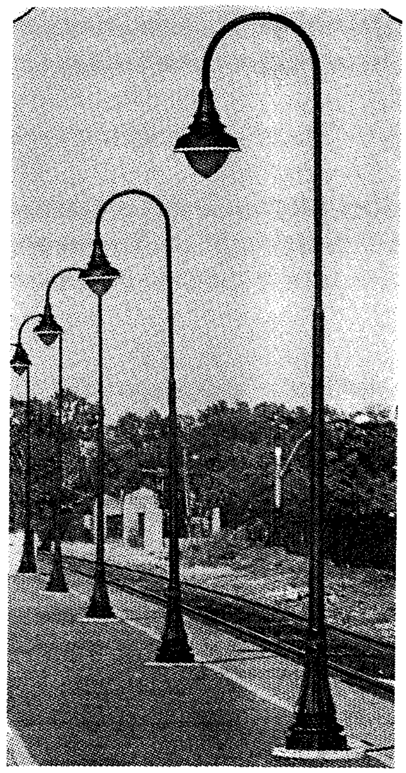


Fig. 2-113
Possible Platform Lighting

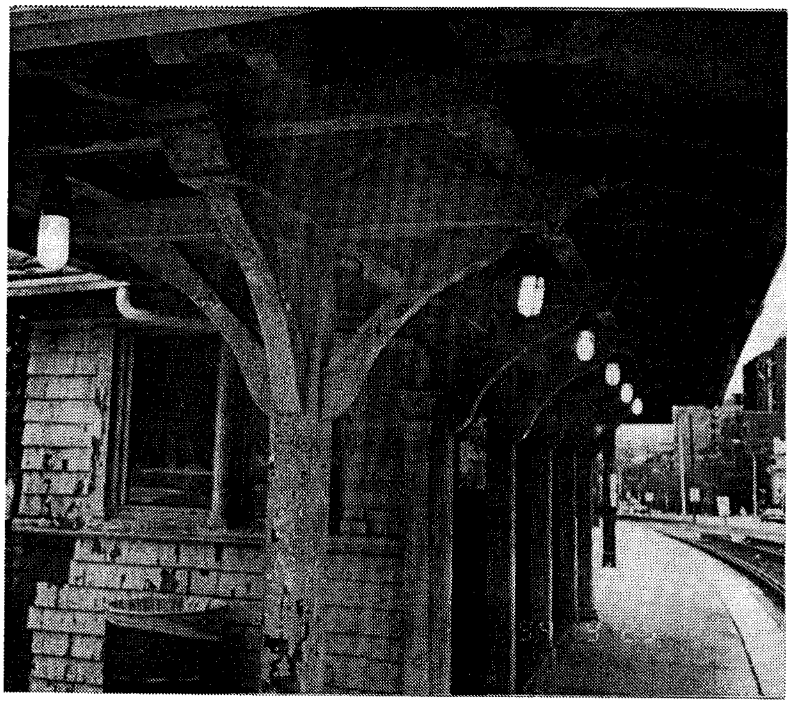


Fig. 2-114
Lighting at Coolidge Corner Canopy

At the historic station shelters the authority should be consulted as to fixture type and lamping.

Subway Station Fixtures

Subway Station Fixtures

The existing fixtures within the subway stations can be reused for the most part.. Some of the fixtures may need to be raised in order to relate to the new raised platforms and furnishings.

If the MBTA decides to renovate the stations completely and concurrently with the implementation of the accessibility program, new light fixtures would be considered as part of the total design.

Lighting required at new subway station headhouses should be designed to be integrated into each context and headhouse design.

Illumination Levels

Illumination Levels

The following illumination levels satisfy the guidelines discussed above. The designer may, however, deviate from the standards listed below to compensate for specific operating or site conditions.

Location	Average Foot-candles
Interior Platforms	30
Platform Edges	50
Exterior Platforms	5-10
Fair Collection Booths	50
Canopies	10-15
Shelters	15
Stairs	10-15
Underpasses, Enclosed Overpasses	15
Elevators	50
Sidewalks and Overpasses	5
Ramps	5

Optical Considerations

Optical Considerations

In the design of station building and site lighting, the contrast between various surfaces within eye contact should be maintained at ratios that will not reduce visual acuity, result in visual discomfort, or cause direct or reflected glare.

1. Contrast Ratios

   The ideal contrast ratio between illuminated areas and adjacent or surrounding areas should be limited to 20:1. In no case should it exceed 80:1. The contrast between emphasis lighting and surrounding surfaces should not exceed a ration of 3:1. The relative levels of luminance of signs and information panels to adjacent and background surfaces should not exceed a ratio of 5:1.

2. Glare

   Luminaires should be designed and located to prevent the source's full brightness from being visible to the eye within normal viewing angles.

3. Reflected Glare

   The angle of view of a vertical surface should exceed the angle at which light strikes the surface to avoid direct reflections from the source.

4. Methods of Control

   Contrast ratio, glare, and reflected glare can be controlled through use of the following:

   - Diffusers to moderate source brightness when ever possible.
   - House side cut-off shields to minimize illumination directed to rear of luminaire.
   - Indirect lighting, such as "wall washing" with light, to control glare and reduce the contrast ratio between a light source and the surrounding environment.

- Parabolic reflectors within light fixtures are especially useful with high intensity lighting near residential neighborhoods to control a light source without sacrificing light intensity on the lighted surface.
- Contrast ratios and glare can, of course, also be controlled by adjusting the location and intensity of the source.

Emphasis of Hazardous and Transition Areas

Emphasis of Hazardous and Transition Areas

Higher levels of light should occur at potential danger or decision areas (stairs, track crossings, street crossings, platform edges, hidden corners, railings, and signage). This illumination should be at least 10 foot-candles at the surface being lighted.

Emergency Lighting - Subways

Emergency Lighting - Subways

Emergency lighting shall be provided in all egress paths, platforms, stairs, enclosed station buildings and fare collection booths. The system will be a diesel powered emergency generator mounted at the station.

Lighting of Historic Stations

Lighting of Historic Stations

1. Original fixtures should be restored and used in historic station buildings wherever possible. Where feasible, inadequate lighting levels should be upgraded through the use of indirect and concealed lighting.

2. The effect of source light on color rendition must be considered. Lamps should be chosen to enhance station colors. Incandescent and warm white fluorescent will be acceptable in most applications, although incandescent fixtures are not generally used by the Authority. Mercury vapor and metal halide may have to be mixed with incandescent to bring out warm colors. High pressure sodium, in most instances, is likely to detract from an historic station's appearance.

3. Renovation or restoration work at historic stations will require coordination with the Authority and historical commissions.

General Luminaire Selection Criteria

General Luminaire Selection Criteria

Luminaires used at all light rail stations should meet the following criteria:

- Function effectively for a minimum of 20 years.
- Resist vandalism, with polycarbonate or high impact acrylic diffusers and vandal-proof access devices such as latches, screws, and locks.
- Minimize maintenance time and costs. Replacement of lamps and ballasts shall be easily accomplished. Lamps and ballasts shall be readily available and standardized to the greatest extend possible. All lenses, diffusers, access devices, and fasteners shall be of the captured type, hinged and removable to provide easy access and prevent loss or damage of parts.
- Contain only non-corrosive materials.
- Function effectively within a -20° to +110°F ambient temperature range (-28°C to +43°C).
- Provide fixture enclosure that keeps moisture and dust out, but allows heat to dissipate.

General Lamp Selection Criteria

General Lamp Selection Criteria

1. A variety of lamp types is available today. Three factors should be considered in selecting the lamp type.

   - Lumen/watt efficiency of the lamp.
   - Effect of the light source color on the surface color appearance of the surrounding areas and objects.
   - Mounting flexibility.

2. Due to the effect of light source color on surface color appearance, the result of lamp choice on user perception should be considered. A given lamps lumen/watt efficiency and mounting flexibility should also be considered.

3. The lamp types available are:

   High Intensity Discharge

   High intensity discharge (HID) is the preferred light source for commuter rail stations because it is highly energy efficient. HID lamps are point light source, electric discharge lamps requiring ballasts. Starting requires several minutes. The three basic HID lamps are:

- Mercury vapor lamps, which emit a greenish-blue light and cause a perceptible shift in color rendition. They are highly efficient (30-65 lumens/watt) with long rated lives (16,000-24,000 hours) and excellent lumen maintenance. Mercury vapor lamps are primarily suited to high bay (over 13'-0" mounting height) applications. These lamp sources will generally not be appropriate for this application.

- Metal halide lamps, which produce a white light. Color rendition is at least equal to mercury vapor. Metal halide lamps are smaller in size than mercury vapor lamps, yet produce a substantially greater output of lumens/watt.

- High pressure sodium lamps, which emit a distinctly yellow-orange light and have a very perceptible effect on color rendition. High pressure sodium is the preferred HID lamp because it is the most cost efficient lamp currently available (approximately 100 lumens/watt). It should be used for lighting large exterior areas such as parking lots, platforms, and walkways.

Fluorescent

- Available in several colors. Warm white fluorescent lamps produce good color rendition and mix well with incandescent. Cool white lamps tend to dull warm colors and intensify cool colors, but are the most efficient (lumens/watt) fluorescent color. Fluorescent is a linear light source characterized by higher light efficiencies, cooler operating temperatures, and longer life expectancies than incandescent.

- Fluorescent lamps are effective in low and medium level lighting applications due to their efficiency and low source brightness. Fluorescent lamps are appropriate under most interior conditions and preferred over incandescent by the Authority. They are recommended for lighting under canopies and shelters. A fixture such as the

NU-ART, MTL series shown in the accompanying illustration is the preferred canopy fixture except at stations prone to high levels of vandalism.

- The recommended canopy (and other strip lighting application) fixture at stations with extreme vandalism problems is the NU-ART POC series fixture.

Incandescent

- Somewhat yellowish with little effect on color rendition. Incandescent lamps are the least efficient light source (lumens/watt) and should be used selectively. It is generally recommended that higher voltage lights be used with lower voltage power to prolong life and, therefore, improve system efficiency. Incandescent lamps are best suited to interior applications where color rendition is important and for special purposes, such as in highlighting of signs, the replacement of existing fixtures, and the lighting of historic buildings. Incandescent lamps should not be used in general station site lighting.

2.7.2 Wiring

At all surface stations new platforms are planned, underground wiring shall be used. Underground wiring in a minimum 1-1/2" galvanized rigid steel conduit is preferred.

Interior wiring should be concealed whenever possible.

Any exposed wiring must be enclosed in conduit. the conduit should be installed in a manner consistent with the following criteria:

- Follow architectural structural members, moldings, or ornamental details in as unobtrusive a manner as possible.
- Match the color of the background on which it is mounted.
- Resist vandalism with supports at a maximum spacing of 2'-0" within 9'-0" of ground level.

2.7.3 Distribution, Metering and Control Components

Review existing electric service conditions and determine adequacy with new loads.

Surface stations requiring power from the utility company and shall be provided with utility metering.

Outdoor control centers shall be provided at all unmanned stations, or virtually all of the light rail systems stations. They shall be weatherproof and will typically contain utility company metering equipment, switches, main and distribution circuit breakers, and time and selector switches.

Switches utilized in light rail station lighting systems include:

1. Manual Switches

   These allow great flexibility since they provide light only when necessary. Manual switches should be installed only at manned stations.

2. Photoelectric Switches

   The preferred type of switch, the photoelectric units are fully automatic and provide light for the duration of the night. Photoelectric switches are particularly applicable at locations where security and safety is a concern, such as shelters, station buildings, and track crossings.

3. Time Switches

   These are fully automatic and provide light at pre-set hours. They should be used only at stations with low levels of vandalism. Time switch components include such features as a seven day or astronomical dial, manual bypass lever, and sixteen-hour power reserve units. They should require only occasional resetting. Time switches are most appropriate for parking area and platform lights that need not operate during the entire night.

2.7.4 Exterior Fixture Mounting and Location

1. The following general fixture mounting criteria apply to light rail surface stations. where new lighting is being installed.

   - Minimum clearance between the bottom face of the luminaire and ground level is 9'-0"; the preferred clearance is 15'-0".
   - Placement should be beyond the reach of persons standing on benches, trash receptacles, retaining walls, or other site furniture.

2. Criteria listed below apply to pole-mounted fixtures:

   - Fixture Height: Minimum of 15'-0" in platform areas.
   - Location must be accessible for servicing by a bucket truck.
   - Poles shall be fixed, rather than hinged type base.
   - Steel poles shall be galvanized or may use "color-galv" in special locations. Do not use aluminum poles. Experience indicates that they break more readily than the steel pole.
   - Poles shall have handholds.
   - Fixture shall have individual cut-off control.
   - Poles shall be mounted on a base extending a minimum of 2'-0" above finished grade at locations where poles are susceptible to damage by snowplows or other vehicles.
   - Shorter poles (10'-0" - 20'-0" long) shall be able to resist damage from "whipping" and other acts of vandalism.

3. A typical pole-mounted fixture which meets the above criteria shall be located as follows:

   - Platforms and walkways: spaced as needed to meet criteria for light levels, mounted on 15'-0" high standards.

4. Fluorescent fixtures should meet the following criteria:

   - Be available in standard 4'-0" and 8'-0" lengths.
   - Provide single or double bulb capacity.
   - Have 430 or 800 ma bulb capability.
   - Have a capability for use as a strip or individual fixture.

5. Existing poles to be revised. Where directed existing pole lighting shall be reused. The poles will be relocated to allow new raised platforms to be installed. The poles shall be located as to allow the maximum clearances and provide access for maintenance.

2.7.5 Subway Fixture Mounting and Location

1. The following general fixture mounting criteria apply to light rail subway stations.

   - Platform lighting fixtures are typically fluorescent light fixtures custom made for the MBTA. They include wiring for communications and D.C. lighting systems. These are typically pendant mounted in continuous rows at the trackside and back of the platform. These fixtures will be required to be relocated to a minimum height of 8'-6".

   - Additional platform fixtures may exist for platform lighting. These are typically pendant mounted or recessed in ceilings.

     Typically they will remain undisturbed. However, in specific areas they will be required to be relocated or removed entirely.

2.8 Canopies and Shelters

Canopies and/or shelters are provided at most key surface stations in order to protect transit users from the elements. As part of the key station accessibility project, these structures must be made accessible, if they are not currently. They will also be affected when they interface with the raised platforms.

Fig. 2-115
Existing Canopy at Newton Center

In addition to existing MBTA guidelines concerning issues such as height, some important access guidelines concerning canopies/shelters are:

- Canopies/shelters should be located along the platform or in station plazas on level areas.
- Canopies shall have roofs that project out at least 5′, where clearance permits, so that a person using a wheelchair will be completely covered.
- If a canopy or shelter provides seating,and space permits, the layout shall allow for at least 2 wheelchairs. (This is an *MBTA Guide to Access* recommendation. ADA only requires space for one chair.)
- The interior space of a shelter must contain a 5′ turning radius for wheelchairs.
- All openings into shelters should allow 34″ clear width.

There are no ADA or AAB requirements for canopies at Light Rail Stations; however, it is MBTA polict to make existing or new canopies and shelters accessible. Stations, currently not part of the key station project, may or may not have canopies/shelters. It is the MBTA policy to provide canopies, if space permits, at those stops that will be made accessible as part of a future project.

2.8.1 Existing Canopies/Shelters

Existing canopies/shelters can be organized into four categories:

1. Historic Buildings or structures
2. Cantilevered prefab metal and Plexiglas canopies
3. Semi-enclosed prefab metal and Plexiglas shelters
4. Semi-enclosed wood structures

Historic Buildings or Structures

Historic Buildings or Structures

Coolidge Corner and Newton Center are the two Green Line stations with historic structures.

Fig. 2-116
Existing Shelter at Coolidge Corner

Coolidge Corner has two nearly identical shelters, built in 1900 in the Craftsman Style, consisting of much painted heavy timber framing, with extended roofs along the platform, and a waiting area enclosed on three sides with built-in seating along the walls. One of the shelters has a supervisor's booth built into one corner with a small door from the waiting area. The other shelter has a free-standing booth of wood in poor condition. Exterior walls of the waiting area are covered in wood shingles originally Forest Green in color. Clear glass windows above the seating are framed in wood with some elaboration in the form of mullion colonnettes. Shelter roofs are of low pitch covered in heavy red terra cotta tiles typical of the period. They have a number of missing pieces and damaged areas. The eaves have modern metal gutters with clumsy rain leaders, to a cast iron below grade drainage system.

Newton Center Station, listed on the National Register of Historic Places, is a Richardsonian Building, built in the early 1900's. Here the canopies are simply an extension of the main gray slate roof of the station, supported along the platform by heavy timber posts and framing which continue the system of wide eaves on the building and are supported on diagonal braces of ornamental as well as functional character. This canopy system is in generally good condition, requiring only minor repair and appropriate re-painting. Any modifications or repairs would need to be approved by both the Newton and Massachusetts Historical Commissions.

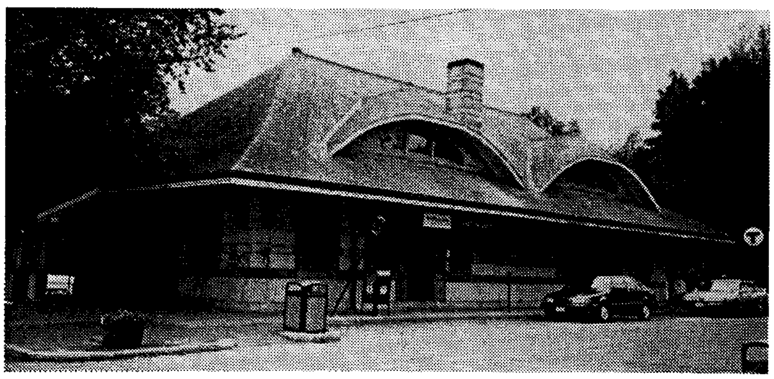


Fig. 2-117
Existing Shelter at Newton Center Station

Cantilevered Metal and Plexiglas Canopies

Cantilevered Metal and Plexiglas Canopies

These canopies are the most common form of shelter on the Green Line surface stations and can be found on the B, C, and E Lines. They provide some weather protection and, unlike other types of shelters, can be used in areas with dimensional constraints. In many of the older structures, the plexiglas surfaces have become scratched and opaque. The supports are often rusted and in poor repair. Therefore, it is feasible to reuse these only on the E line. Other lines will require new canopies.

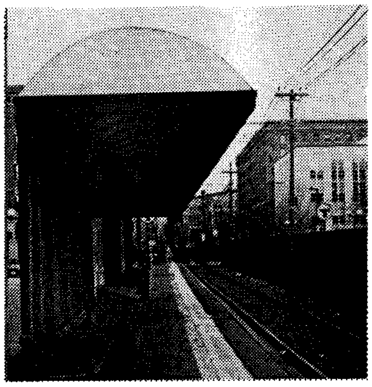


Fig. 2-118
Existing Canopy on E Line

Fig. 2-119
Existing Canopy to be replaced on C Line

Semi-Enclosed Wood Shelters

Semi-Enclosed Wood Shelters

Wood Shelters, although not historically significant, are located mainly on the D Line. They may need to be modified to allow for people using wheelchairs and future raised platforms. Most of them should be repainted and appropriately renovated, if not replaced.

Fig. 2-120
Existing Wood Shelter at Brookline Village

Semi-Enclosed Prefabricated Shelters

Semi-Enclosed Prefabricated Shelters

Prefabricated metal and plexiglas shelters currently exist in several locations along the line at both transit stations and bus stops. The plexiglas surfaces have become opaque, they are often placed in inappropriate locations, and in general should be replaced, if at all, with a design that is more site specific.

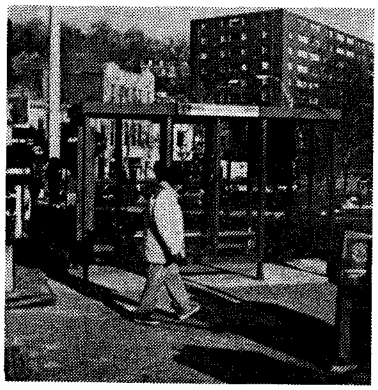


Fig. 2-121
Existing Shelter at Washington Square

Fig. 2-122
Existing Shelter at Fenway

2.8.2 Proposed Design Criteria

Based on an analysis of the existing canopies/shelters and where they will require replacement, the following design guidelines were developed:

Canopies

Canopies

New canopies will be required on the B and C lines. The canopies on the E Line will be reused in modified locations. Design criteria for new canopies are as follows:

- Canopies should provide continuity within a specific line, yet allow flexibility for site specific design opportunities. ***Fig. 2-126*** illustrates that concept using a high catenary like support structure, within which spans canopies of varying forms. This will provide the rider with a specific station identity, yet allow for common materials and maintenance schedules.

- Canopy structures shall be designed to be as transparent and lightly framed as possible. This will provide open surveillance as well as decrease their imposition on the streetscape. ***Fig. 2-123*** shows an example of a transparent, lightly framed bus shelter used in another city.

- Canopy supports shall be integrated into the overall platform design to present a consistent and well designed image.

- Maps and other solid panels shall be located separately so that critical information is not blocked by people sitting or standing under the canopies.

- Benches (or flip up benches), see Furnishings, shall be located under canopies, with open areas where wheelchairs can park.

- Canopies shall be located away from the intersection, so as to keep view lines open and avoid bottlenecks at the entrances of the platforms.

- On narrow platforms, canopy supports shall be located in the "clear zone" (See Platform Chapter) and be between 18 and 25 feet in length. (Exact length will depend on final design and proportions of the canopy).

Fig. 2-123
Example of Transparent Canopy

Fig. 2-124
Existing Canopy Support

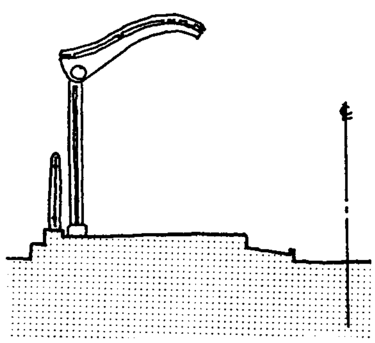


Fig. 2-125
Example of Proposed B-Line Canopy

2.8 Canopies and Shelters

Fig. 2-127 shows an image of a platform with all elements integrated.

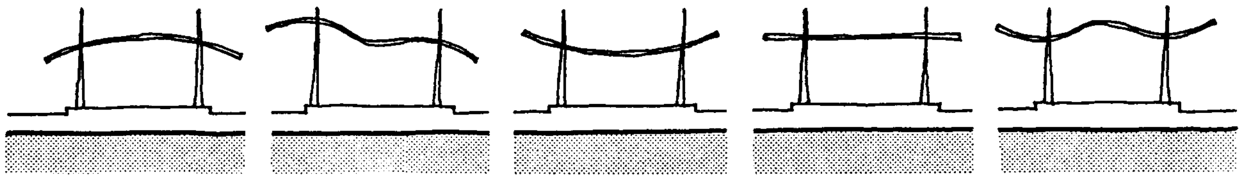


Fig. 2-126
Possible Canopy Concept

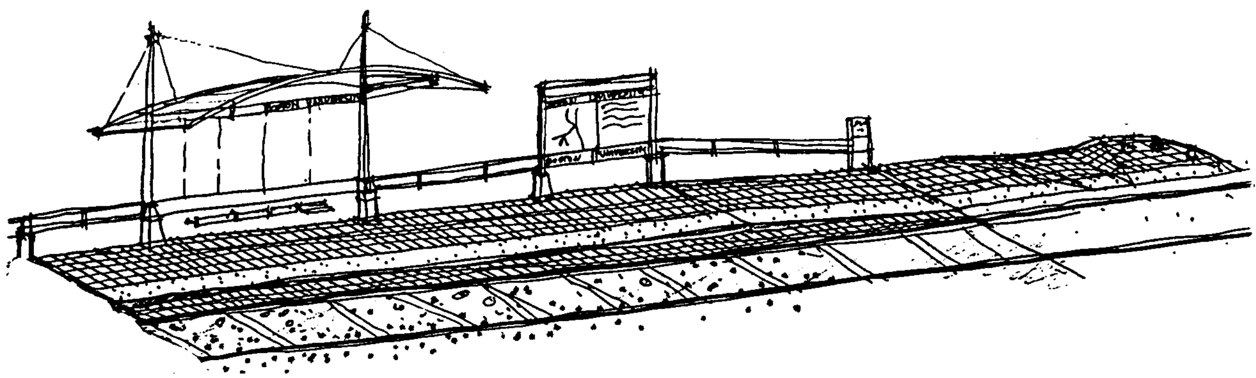


Fig. 2-127
Possible Concept on Surface Platform

Historic Structures and Other Wood Shelters

Historic Structure and Other Wood Shelters

Historic and other wood shelters, located mainly on the C and D lines, should be maintained and restored.

Fig. 2-128
Granite Base at Newton Corner

***Newton Center*:** In order to avoid difficult adjacency and interface problems with the Newton center Station, the rail bed will be lowered at this station. Raising the platform would have a clearly adverse effect on the station's carefully designed exterior stairs and stone work. The appearance of the granite base course of the walls would be seriously impaired if its height above the pavement were reduced. The reviewing authorities would be unlikely to approve such a change. The wood structure across the track should be redesigned to reflect the Richardsonian Architecture of the main station.

Fig. 2-129
Existing Post at Coolidge Corner

***Coolidge Corner*:** The two Coolidge Corner Structures will require lifting and repositioning. New bases will be required to provide adequate headroom under the existing brackets. (See Figures 2-18 and 2-19, Accessible Route.) In addition to moving the two structures and building new foundations, restoration to near 1900 appearance would involve complete paint stripping (with lead paint precautions) considerable repair carpentry and millwork, some reglazing, electrical work and repair to the tile roofs. Fortunately the roof tiles are still being made and are available. Adequate access and interior space would have to be provided for wheelchairs.

Wood Shelters - Plain: The other existing wood shelters should be maintained and renovated as required to provide access to people using wheelchairs and to interface with the raised platforms. Most will have to be lifted and repositioned.

Semi-Enclosed Shelters

Semi-Enclosed Shelters

Where clearances exist, new semi-enclosed shelters may be appropriate. Design guidelines are:

- The existing semi-enclosed prefab structures (see ***Figs. 2-121*** and ***2-122***) should be eliminated and replaced with site specific designs that would give the stations a unique identity. (Similar to what the Coolidge Corner structures do for Coolidge Corner.)
- If existing structures already existing at a station, the new structure should be similar in order to give a unified station image.
- Shelters should be located away from intersections so as to keep view lines open and avoid bottlenecks at the entrances to platforms.
- Benches (or flip benches) should be located within shelters, leaving space for wheelchairs.
- Maps and other information should be located so they are not blocked by people using the shelter

Materials

Materials

Materials for canipies and/or shelters should be chosen to be graffiti and vandal resistant, low maintenance and durable.

- **Metals:** Stainless steel, heavy duty molded aluminum, or black coated ferrous metals are appropriate structural materials. As any coated ferrous material will eventually rust, colors that show rust are not appropriate.

- **Wood:** Wood framing and sheathing should be fire and weather treated. A solid body stain, as opposed to paint, should be used to finish all wood materials.

- **Glass:** Current glass technology has created almost vandal resistance laminated glass panels. Unlike the lexan panels, which scratch and discolor, glass will stay transparent. Station architects should explore using glass panels (9/16" min.) where transparency is required. Solid glass block should not be used if transparency is a goal.

- **Lighting:** Lighting should be incorporated into the canopy/shelter design for safety, as a station announcement element and a design element. (See *Lighting* section of this material.)

2.9 Communications Systems

The MBTA has begun design activities to make Light Rail stations accessible in accordance with ADA requirements. A portion of this work will affect communications equipment.

2.9.1 Existing Systems

The following is a summary of the communications on the Authority's trolley lines.

- public address (PA)
- closed circuit television (CCTV)
- train approach annunciation
- in-house and public telephones
- police talk-back
- emergency communications
- clocks

Cabling requirements vary throughout the system. Some areas now utilize fiber optic cable, while most are still dependent on copper.

Certain areas are more developed with communication systems than others. Typically, the subway stations have a full array of communication equipment, while most surface stations have little or none. ADA compliance impacts a number of these systems: public address, telephones, emergency communications and clocks. Improvements to the train annunciation system may also be appropriate for consideration.

At subway stations, public address, telephone, emergency communications and clocks will need to be addressed. on the surface lines, most stations are unaffected. However, there are public address systems at four Highland Branch (D Line) stations that will require consideration for upgrade, including the installation of accompanying LEE signage. Of the two Red Line stations, Ashmont and Mattapan, only Ashmont will require significant consideration, since, as a subway station, it has both public address and telephone systems.

With respect to this contract, there are four surface stations on the D Line and six stations in the subway equipped with public address systems. The surface stations have very little in terms of existing equipment: 2 to 12 speakers, s small enclosure to house a mixer and amplifier, and a leased telephone line to link the system to the Operations Control Center (OCC) . To upgrade in order to provide simulcasting of LED signage, the costs will be considerable as the existing equipment will not support the additional equipment required. A new public address system, possibly with new dedicated cabling, may be in order for several stations, including Fenway, Brookline Village, Newton Center and, to some extent, Reservoir.

The subway stations, if the system upgrade is limited solely to installation of LED signs, will also have considerable costs. The magnitude appears to be approximately half that of the upgrade for the surface stations. The reason for this is that the subway stations are better equipped with existing public address system components and cabling and may be readily suited to accept the additional installation of LED signage.

2.9.2 System Components and Compliance Standards

Communications systems are to be designed to provide for safe operation of equipment, ease of maintenance, expandability, and long life. All equipment and structures are to be designed to the latest codes and standards available at the time of the design and are to incorporate field-proven technology. Section 4.4. Electrical provides design criteria and guidelines for the preparation of drawings and specifications for communication systems.

Station designs shall comply with the following standards:

- MBTA guidelines and standards
- Federal State and Local Codes
- National Fire Protection Association
- Massachusetts Architectural Access Board
- Americans with Disabilities Act
- Design guidelines for meeting the access needs of blind and visually impaired travelers in transportation terminals - published by Transport Canada and the Canadian National Institute for the Blind
- Transit Facility Design for persons with visual impairments - published by the U.S. Architectural and Transportation Compliance Board.

The following are descriptions of the communication systems and requirements for meeting compliance standards.

Public Address

Public Address

Exists at all subway stations and certain surface stations. At subway stations, speaker coverage is extensive in platform areas only. Collector's or station entry areas are not usually covered or have limited coverage. At surface stations, the number of speakers is limited (e.g. Brookline Village has two, Fenway has 3 pair), and coverage and transmission quality is questionable. Subway stations are typically controlled over the Authority's cables, and surface stations are controlled over telephone company leased lines.

Where public address systems are in place, ADA regulations mandate the need for a means (electronic signage or video) of conveying the same information to persons with hearing loss or who are deaf. Video simulcasting of audio messages should be provided at locations with existing public address systems.

Local paging would be initiated from the Collector's Booths, the Inspector's Rooms and Train Starter's Room by using a P.A. Control box which is located in each of the above rooms. Paging is also accomplished by the Loudspeaker Monitor Panel which is located inside of the public address cabinet in the Communications Room. The public address system and electronic sign system shall be interfaced to provide simultaneous audio and visual information. The public address system shall meet the criteria of Chapter 15, Installation Practices, Sound System Engineering, Donald and Carolyn Davis, 2nd edition.

The P.A. system shall interface with the existing PCM Carrier System to allow remote paging from 45 High Street to be received by each station.

The electronic sign system provides for distribution of passenger information via LED scrolling bulletin boards located throughout each station lobby and platform area. Each electronic sign displays a message developed and transmitted from the existing computer equipment located at Dewey Control Center, 45 High Street, Boston.

Telephones

Telephones

Public telephones are present in all subway stations, with the busier stations have a great number of phones. The surface stations vary in phone coverage, some having phones on site, some with phones in the vicinity on public sidewalks, others with none.

New public telephones shall be provided meeting ADA and AAB standards, including compliance related to height, activation, access and amplification. One TTY (Text Telephone) is required at all interior locations where telephones exist.

The MBTA is presently looking to work with NYNEX on an overall system upgrade in this area involving many locations. Limits between this LRAP contract and an overall transit system telephone upgrade have not yet been completely determined.

Police Talk Back

Police Talk-Back

The MBTA police talk-back system provides voice communications with the MBTA Police Dispatcher at Headquarters at Cabot Yards. A passenger requiring assistance from MBTA Police depresses the push-button on one of the call boxes located throughout the station. The talk-back system senses the request and notifies the dispatcher. The systems shall be modified or relocated according to the scope at each station.

Emergency Communications

Emergency Communications

ADA regulations also require a method of two-way communication with both visible and audible signals between areas of rescue assistance, if provided, and the primary entry. Similarly, if elevators are quipped with audible two-way communications, a visual indication that a rescue is on the way shall also be provided.

Clocks

Clocks

Where provided in some subway stations, clocks are required by ADA to have uncluttered faces with high contrast letters. If mounted overhead, the letters must be 3-inches high minimum.

2.10 Landscaping

Landscaping and paving are other elements of the site design which can greatly effect the overall character of each station. While adding natural beauty and controlling erosion, plant material also provides protection from the sun, rain, and wind. Paving materials and patterns can help direct pedestrian traffic, orient users, and provide a link with the existing materials of the surrounding area. Subway stations have no existing landscaping and there are distinct differences in the landscape character of the branch lines:

- "B" Line
  This branch of the Green Line occupies the median between the east and westbound lanes of Commonwealth Avenue leaving little space for landscaping, and only at the Boston College station does any planting exist.

- "C" Line
  Beacon Street provides the boundaries for the stations along this tree–lined branch of the Green Line. All efforts should be made to maintain the character of these stations by preserving as much of the existing vegetation as possible, and adding more wherever feasible, to reinforce the "green" median.

- "D" Line
  This branch varies greatly in character. Fenway and Longwood have little or no landscaping. Newton Center and Reservoir are heavily vegetated.

- "E" Line
  None of the three surface stations on this branch has existing landscaping.

For discussion of bollards, fencing, lighting, and platform paving, please refer to Sections 2.11.4, 2.11.2, 2.7, and 2.4 respectively.

2.10 Landscaping

2.10.1 Planting

Existing Planting

Existing Planting

The value of mature existing foliage cannot be understated; therefore, all efforts should be made to retain and protect prominent existing vegetation which is in good condition. Planting in public areas, and near transitways, in particular, can suffer from the harsh environment, vandalism, and lack of maintenance. Existing vegetation which is thriving can be an excellent starting point for establishing a plant list for each station and its preservation can help reduce the cost of proposed plant material. Each station landscape architect should conduct a thorough inventory of existing plant material and notation made as to which specimens should be protected, which transplanted, and which removed.

New Planting

New Planting

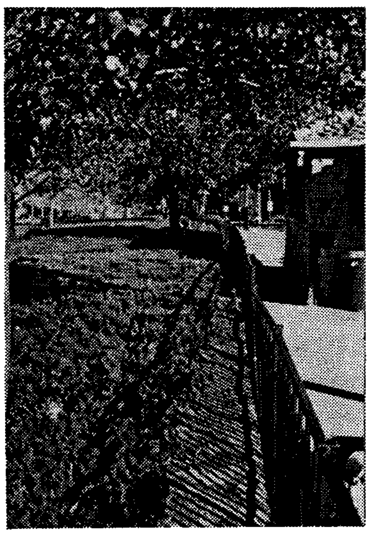


Fig. 2-130
Planting between Platform and Adjacent Roadway

Whenever possible, surface stations should have some planted areas. Ideally, a buffer of planting between the platform and the adjacent roadway is preferable over fencing alone. In the case of median–type stations, trees planted near the platform should allow a view through from one side of the street to the other. For reasons of security and safety, plant materials must allow surveillance of the station area and must not overhang the tracks. Trees and shrubs shall be planted no closer than 5′ on center to the transit/rail retaining walls, or to the portals of bridges and decks. In the case of trees with large canopies, the distance shall be greater. Subway stations may have an opportunity for planters at the street level entrances and for trees in grates on some sidewalks.

Trees

Trees

Trees planted in paved areas shall be provided with cast iron tree grates, frames, and guards where space permits. The opening between the slots of the grate shall be no greater than 1/2″ and the long dimension must face perpendicular to the predominant direction of travel. This prevents wheelchair and bicycle wheels from getting caught in the slots. The recommended style for tree grates and guards is shown in ***Fig. 2-131.***

To meet overhead clearance requirements, trees located in paved areas shall be pruned so that their lowest limb is a minimum of 6′-8″ from the ground plane, but a minimum of 8′ is recommended. All plantings should require little maintenance besides watering. The use of grass as a ground cover should be avoided because of its high maintenance requirements. Suitable materials for ground cover include bark mulch and stone mulch.

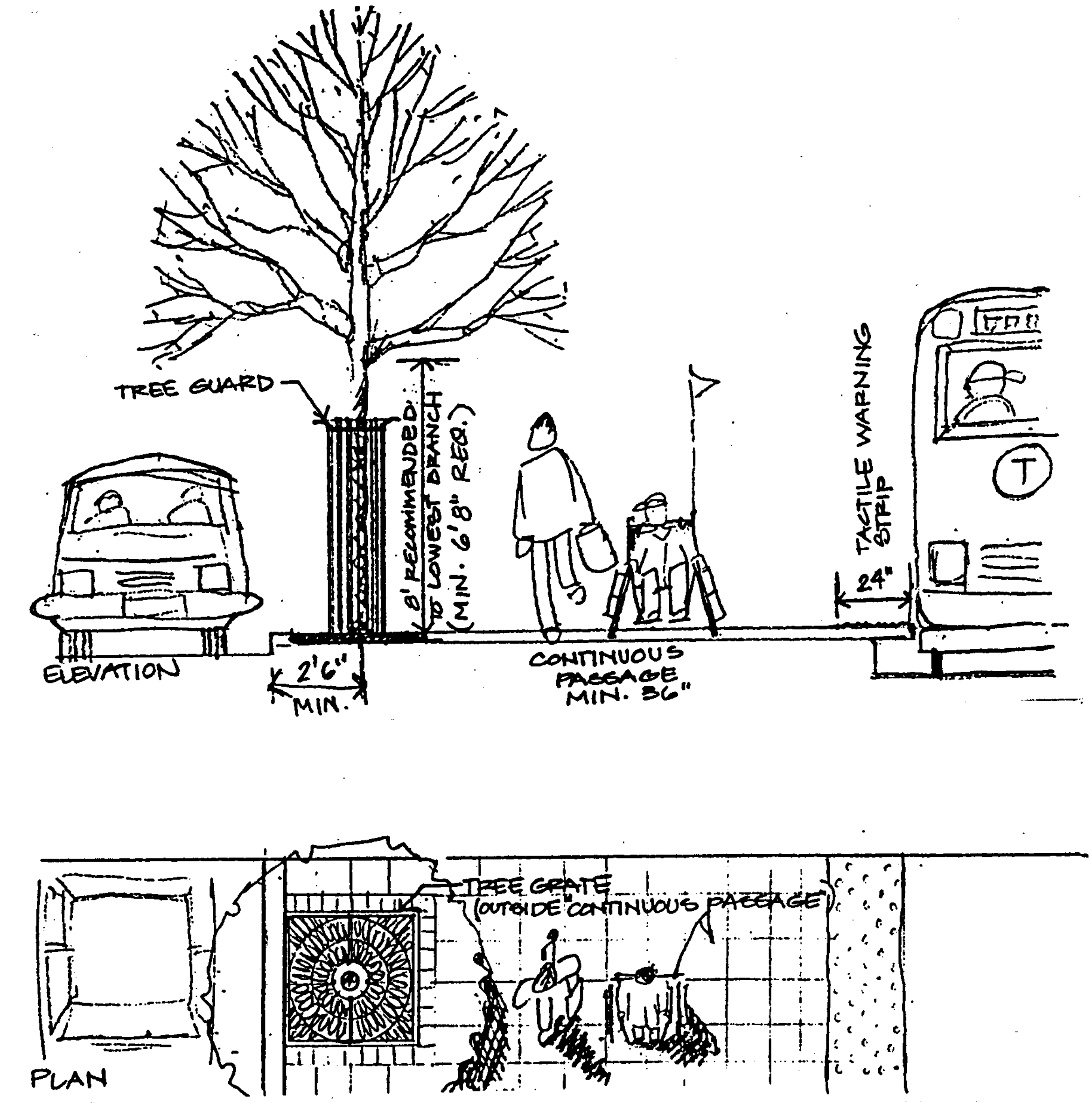


Fig. 2-131
Tree grate, guard, and pruning to meet accessibility requirements

2.10.2 Planters

Planters may be of three types (***Fig. 2-132***), but should in most cases, be limited to one type per station. In all cases, planters must be located so as to maintain the minimum 3 foot wide "continuous passage", they should complement the other site furnishings, be easily maintained and vandal resistant. All planters must have drip irrigation (except moveable) and drainage systems, and be easily maintained.

Large, movable planters are useful for the display of seasonal flowers which can add significantly to the attractiveness of the station. These planters may be constructed of concrete, fiberglass, stone or plastic. Existing whiskey barrels at some stations serve the purpose of containing plants, but are not in keeping with the image the MBTA is hoping to project for its station improvements.

Raised bed planters may be used at stations where space allows. These may consist of a curb– type perimeter constructed of brick, granite, or other suitable material. Trees, shrubs and flowers may be planted in these areas. This type of planter is successful because it requires little maintenance itself and allows for easy maintenance of the plants within it. The definitive separation of uses between a raised planter and adjacent materials creates a clean and easily perceived space.

Raised planters with seating may also be incorporated into the station plans provided there is enough space. These may be constructed of brick, concrete, stone, or any other material suitable for the site and complementary with the surroundings. The height of the seating wall should be 18″ to 22″ the width a minimum of 12″. These raised planters should provide at least a 6″ depth of soil for large shrubs or small trees. They may be useful in places which have utilities or other underground impediments to planting.

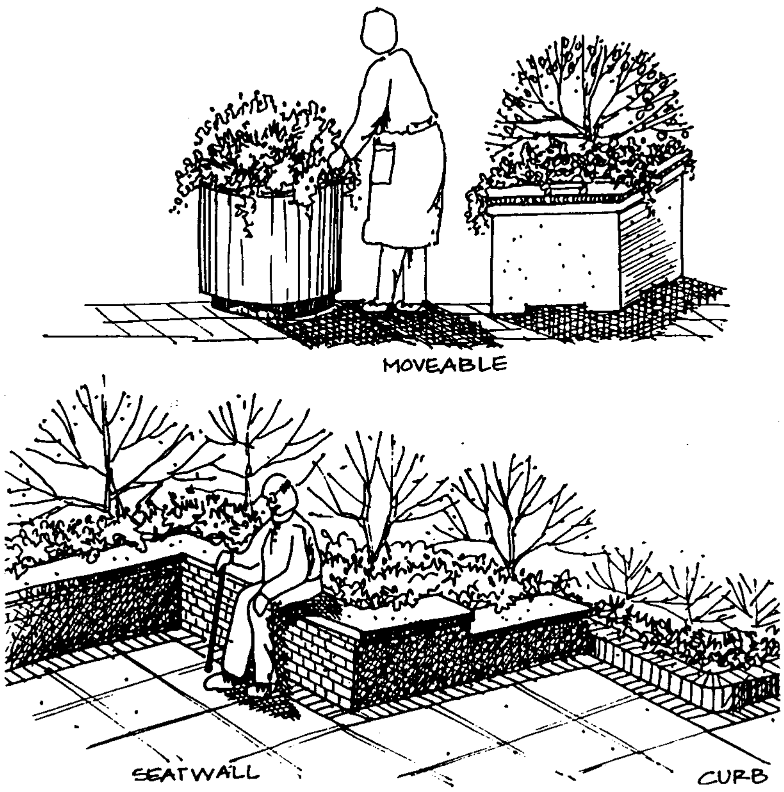


Fig. 2-132
Three types of planters

2.10.3 Paving

Please refer to Section 2.4 for platform paving.

A variety of paving materials are available which meet accessibility requirements and other needs such as durability and attractiveness. Paving materials of public sidewalks must be stable, firm, and slip–resistant and shall lie generally in a continuous plane with a minimum of surface warping. Walkway surfaces must have no abrupt changes of level greater than 1/2", and any changes between 1/4" and 1/2" must be beveled with a maximum slope of 1:2. The cross slope of walkways and plazas should be a maximum of 2%. Suggested materials for paving include unit pavers such as: concrete pavers, brick, or granite. Granite cobbles may be used in areas that are not meant for pedestrians. Large expanses of concrete or asphalt are not recommended. Snow removal and other maintenance requirements must be taken into consideration.

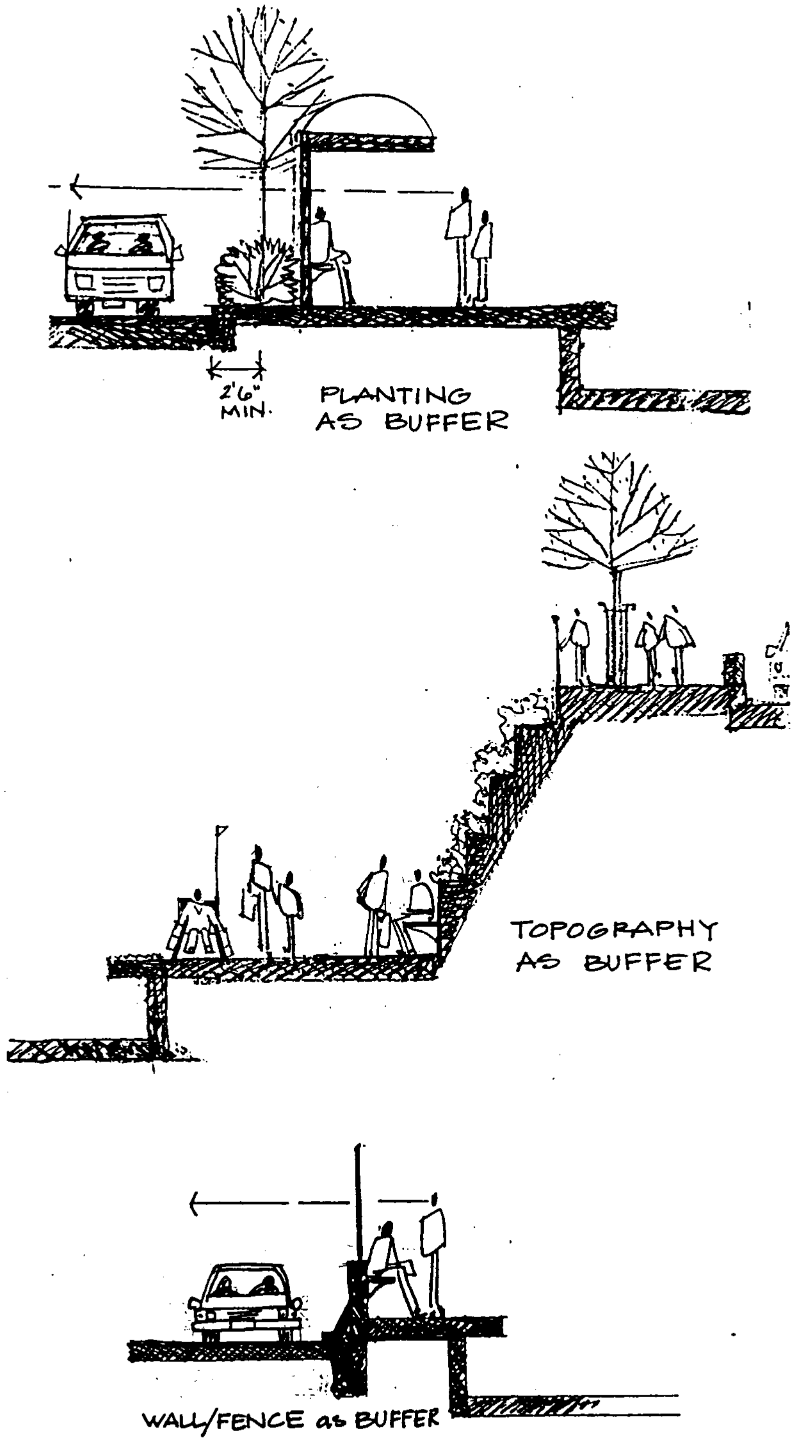


Fig. 2-133
Types of Buffers

Scoring patterns of concrete and unit paving patterns should be kept simple yet succeed in orienting users by helping to define routes of travel and spatial organization. The incorporation of art work into the station area paving may consist of simply the name of the station or more elaborate depictions of selected elements which characterize the neighborhood.

2.10.4 Buffers

Buffer Types

Buffer Types

Various types of natural and man-made devices can be used to visually and physically screen incompatible land uses or to reduce the impact on the surrounding area of the noise from the moving trains. Some of the buffers that may be used include planting, fencing, existing topography, and earth berms.

The location of visual buffers will, of course, vary with the site. In general, however, they should be located at the perimeter of the site in a manner that insures uninterrupted visibility at all pedestrian–vehicular intersections. Buffers should not reduce the effectiveness of site security and lighting and should not completely screen the platform areas from the surrounding neighborhood and streets.

Plant Material

Plant Material

The use of *plant material* as a buffer can be effective when used alone or in conjunction with topographical features or fencing. The general effect of planting buffers will be to lessen the visual impact of the station on the adjacent area, rather than to create a complete blockage of sight lines between the station and the surrounding area. Maintaining at least partial visibility is important for security reasons.

Fencing

Fencing

Fencing is another alternative for visually screening the station area. Because of expense and maintenance, this method should be used only when the other methods mentioned here are found to be unsuitable for a site. Such cases may occur at stations which have very limited space or more stringent security criteria. Since most of the Green Line stations fall into one or both of those categories, fencing will be an important element in the site design of each station.

Fencing combined with planting has been successful at some existing MBTA stations, notably Coolidge Corner. A solid fence is not necessary to create of sense of separation. The standard MBTA iron picket fence modified with a band at the top to cover the pickets is attractive and would be suitable at many stations.

Existing Topography

Existing Topography

At some stations, it may be possible to use *existing topography* to screen the station from the surrounding area. By capitalizing on substantial grade changes, much unnecessary grading can be avoided. Brookline Village and Newton Center are two stations which are characterized by substantial grade changes. At level sites which do not lend themselves to the use of existing topographical features for screening, creating *earth berms* is a viable option.

2.10.5 Topography

The importance of topography in the Light Rail Accessibility Project underlies all components of the landscape and site design of each station. In order to meet the requirements of all state and federal laws and regulations, each public transit station must be made barrier–free and have amenities which are accessible to everyone. A great portion of the improvements that need to be made involve changes in grade, substantial or not. Subsequent stairs, ramps, and paving must then meet all the appropriate standards.

2.11 Barriers

A system-wide series of barriers are presented in this section. These barriers will be required in order to separate the vehicular, transit and pedestrian zones of the system. Low railings at the edge of platforms, mid track fencing, and vehicular barriers with rails adjacent to streets, are described below:

In general these elements should:

- avoid visual clutter in the streetscape by standardizing the design.
- be as transparent as possible in order to maintain visual access across streets and to important architectural elements.
- help integrate the transit system into the streetscape, rather than treat it as a barrier within the street.

In the subway stations open railings around stairs are preferred over parapet walls. On the surface stations where the transitway is located in the center of the street the transit zone should be seen as a part of the street that maintains the visual connection between both sides of the street. It should not become a barrier, or separate zone within the street.

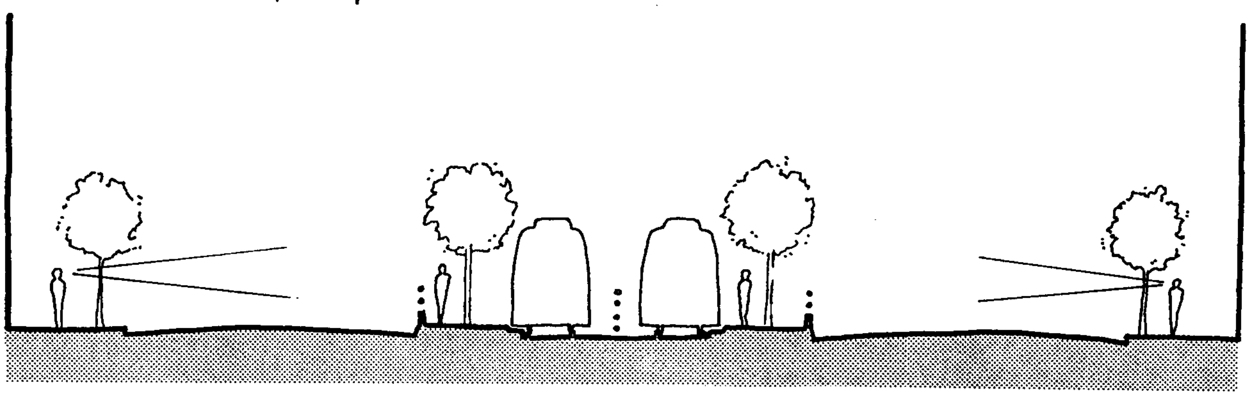


Fig. 2-134
Transitway as part of streetscape

2.11.1 Railings

Railings will be needed at the edge of platforms when adjacent to planting, parking or other buffer zones. These railings will be the same system-wide.

Height amd Materials

Height and Materials

Railings are to be 3'-0" high, wrought iron, painted black, made out of 5/8" steel rods at 6" o.c. supported every 4'-0" with posts. The top should be open with the verticals projecting through. See ***Fig 2-135***.

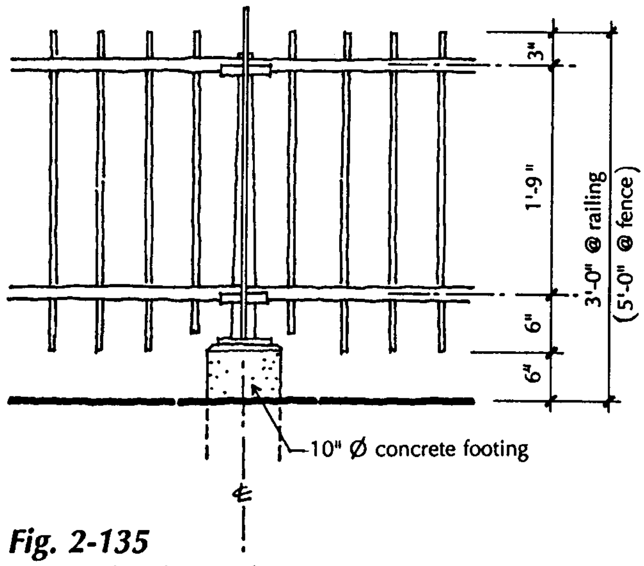


Fig. 2-135
Proposed Railing and Fencing

2.11.2 Fencing

Mid-track or outside fencing is required at stations and other locations where it is necessary to deter pedestrian track crossings. Mid-track fencing requires a minimum of 12'-6" between track centers. If track centers are less than 12'-6" or if the MBTA requests, outside fencing may be used. Fencing shall be a system-wide element.

Fig. 2-136
Existing Mid-Track Fencing

Height and Materials

Fencing shall be wrought iron to match railings, but 5'-0" in height. In no instance should chain link fence be used, especially in mid-street locations. See ***Fig. 2-135***.

2.11.3 Vehicular Barriers

The MBTA is currently planning to use a cast-in-place barrier at all stations where the station platform is adjacent to the street. In order to maintain transparency, the barrier is designed to be as low as possible with a transparent rail on top.

The barrier should be seen as part of a raised curb ribbon creating linear continuity and movement parallel to the line. Because the vehicular barrier with railing is part of the total image of the platform, the station architect should explore ways of integrating its design with the canopies, signage, and other required platform elements. (See *PDM*, 2.8 Canopies.)

Height and Materials

Fig. 2-137 shows the dimension requirements for the proposed vehicular barrier with railing.

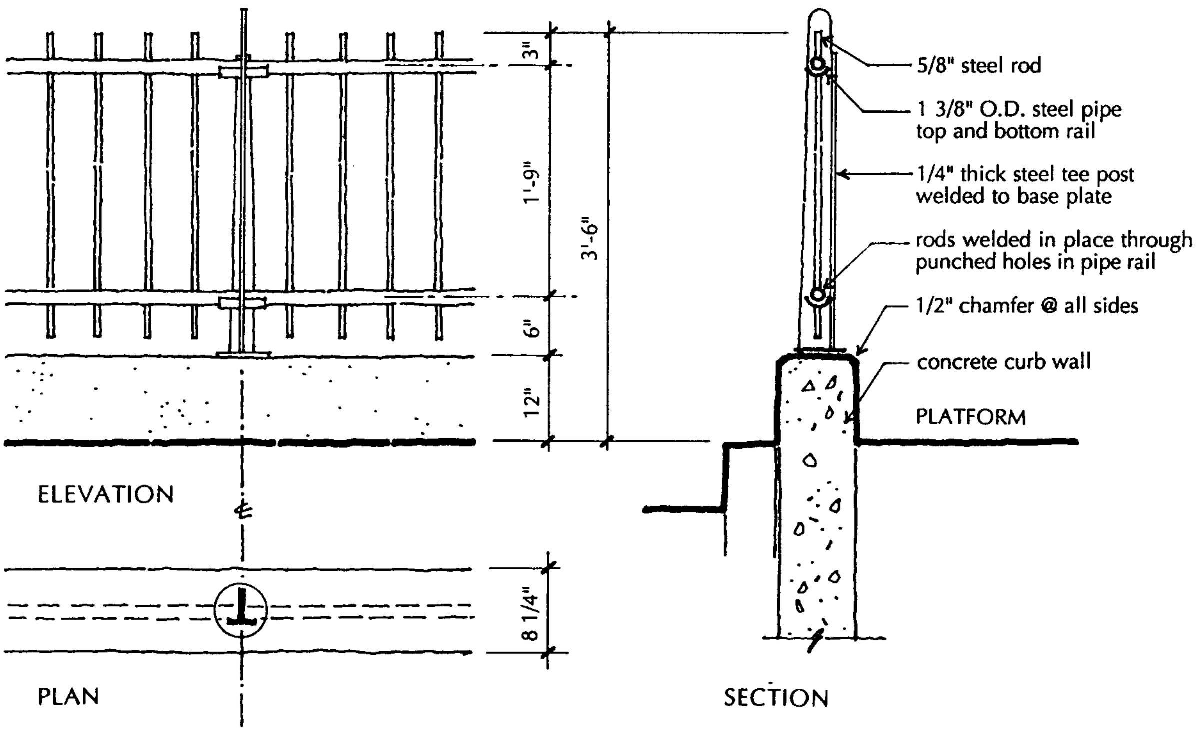


Fig. 2-137
Proposed Vehicular Barrier with Railing

2.11.4 Bollards

Bollards will be used at two different conditions in order:

1. To allow passage for wheel chairs and pedestrians but not vehicles.

2. To protect structures or furnishings from damage at site specific locations.

The bollard design should be based on site specific conditions.

2.12.1 Concessions

Concession stands and vendors currently exist in most subway stations. When they interface with the proposed raised platforms they will need to be removed and relocated. At certain stations, they will need to be replaced at a different location because they interfere with proposed elements or accessible routes.

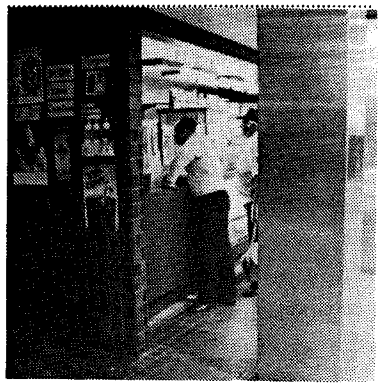


Fig. 2-139
Existing Concession

Since these concession stands must conform to access regulations in regard to counter heights, many of them will need to be modified. (See *MBTA Guide to Access.*) The station architect should coordinate plumbing and electrical requirements associated with removal and replacement of these concessions.

2.12.2 Toilets

Although accessible toilets are not a key station requirement, they may an AAB requirement is the appropriate access requirement is triggered. It is, however, an MBTA policy to provide accessible employee toilets at each subway station. It is assumed that these toilets could be used by the general public with permission.

It is recommended that separate men's and women's accessible toilets be provided at each station. However, if the station architect discovers that it is impossible, one unisex accessible toilet might be acceptable. This should be coordinated with the MBTA and the *State Plumbing Code.*

When the existing accessible toilets interface with the raised platform, they will need to be dismantled and raised up to the new platform level. The station architect should coordinate the plumbing and electrical requirements associated with the addition, removal or replacement of all toilet facilities. Toilets should be designed to conform to the *MBTA Guide to Access.*

2.12.3 Ancillary Rooms

Ancillary Rooms include Elevator and Escalator Machine Rooms, Electrical and Mechanical Rooms, Pump Rooms, Switch Rooms, Pump Rooms, Battery Rooms, Ejector Rooms, Starter's Rooms, Safe Rooms, Porter's Rooms, Vent Rooms, Break Rooms, Storage, Communications Rooms, Inspector's Rooms, and Offices. These rooms exist throughout the subway stations. Generally, they do not need to be accessible.

New, enlarged or relocated ancillary rooms will be part of the accessibility project. For example:

- new machine rooms will be required with the proposed elevators
- enlarged electrical rooms are recommended in most stations to provide adequate floor space for an upgraded electrical service
- existing rooms may need to be relocated to allow for new access requirements that result in modified floor plans.

These rooms are also affected when they interface with the raised platforms. In this event, 3 courses of action could be pursued with regard to the interior of these rooms. The first could be to raise the entire floor of the room, which will require dismantling of some floor mounted equipment and remounting it to accommodate the raised floor. The second option would be to construct a permanent ramp on the interior of the room. The third would be to step down into the room. The last 2 options seem the most economical, but may allow water into a space during the cleaning of the platforms.

Final resolution for the treatment and location of these rooms should be coordinated with the MBTA. When these rooms have to be relocated because of change in floor plan at mezzanine or platform level refer to the *Schematic Design Report* and current MBTA Guidelines.

When they need to be changed in size because of current requirements, for example electrical equipment upgrade, refer to the *Schematic Design Report* and current MBTA Guidelines.

Some new rooms will need to be built, for example new Elevator machine rooms adjacent to the new elevators. See the *Schematic Design Report* and current MBTA Guidelines.

2.12.4 Doors

There are two types of doors that will be affected by the access project:

1. Doors at entrances along accessible routes or to accessible spaces.

2. Doors that interface with the raised platform and/or lobby.

Fig. 2-140
Existing Doors

Accessible Doors

All existing or proposed doors that are located at station entrances along accessible routes or to accessible spaces must conform to the current *MBTA Guide to Access* requirements in regards to width and hardware.

Doors at Raised Platforms

Doors and frames which interface with the proposed raised floors will need to be raised to the appropriate height. Each door and frame should be evaluated as to whether they can be reused in a higher position or if they need to be replaced. Doors into mechanical, electrical and other service areas may need to be raised, however they are not required to be made accessible.

3.1 Existing Light Rail System

The Authority's Light Rail system currently operates in a wide range of physical environments. This is due in part to the fact that the Light Rail system has evolved from the days of street cars which typically shared roadways with other vehicles. As congestion increased over the years, it made more sense to place most streetcar tracks in reservations, essentially eliminating many of the elements which interfere with operational efficiency and safety.

The system operates in the following environments:

The underground portion of the system operates in what is known as the Central Subway. Most of these eleven stations are underground and located in downtown Boston. Eight are classified as Key Stations.

The Commonwealth Ave. Branch (the B-Line) operates on a median reservation throughout its entire length. Of the line's 22 stations, 5 of them are classified as Key Stations. A median reservation is a condition where the eastbound and westbound roadway lanes are separated by the tracks and platforms. The tracks are crossed at grade by intersecting roadways, usually adjacent to station locations. Throughout most of its length, the reservation along the B-Line is extremely narrow, allowing minimal space for platforms. This line terminates at the Boston College Station (Lake St.).

The Beacon St. branch (the C-Line) operates on a median reservation similar to the B- Line. Along much of the line however, the right-of-way is considerably wider, thus allowing larger, more comfortable stations. Four of the thirteen stations on this line are Key Stations. The Line terminates at Cleveland Circle, where tracks are provided to allow trains to transfer to either the D-Line at Reservoir, or the B-Line via Chestnut Hill Ave.

The Highland Branch (the D-Line) operates on an exclusive right-of-way. This means that all roadway crossings are grade separated. The thirteen stations on this line, five of which are Key Stations, are generally similar in character to Commuter Rail stations. The station areas are often depressed below grade, requiring vertical circulation elements.

The Huntington Ave. Branch (the E-Line) operates in two different environments. The first four stations after the tunnel portal are located on a median reservation similar to the B-Line. The remainder of the line, consisting of five 5 stations/stops, operates on a shared reservation: the tracks run down the middle of the paved vehicular roadway, sharing it with cars. Platforms are not provided; passengers load/unload trains directly from the street at designated stops. The E-Line presently terminates at Heath St. where trains reverse direction at the loop. Although currently out of service, this line continues on to the Arborway, operating on a shared reservation.

The Mattapan High Speed Line, which connects Ashmont Station on the Red Line to a station in Mattapan Square operates on an exclusive reservation similar to the Highland Branch. This line currently utilizes PCC trolleys and is considered part of the Red Line even though the trolleys are Light Rail Vehicles. Of the eight stations along this line, only Mattapan and Ashmont are Key Stations.

3.2.1 Light Rail Vehicle Types

With the introduction of the new Low Floor Vehicles, the Light Rail System will be operating four generations of vehicles. Each of the vehicle types are identified below and shown in ***Fig. 3-1***.

The PCC (Presidential Conference Committee) trolleys operate exclusively on the Mattapan High Speed Line. These

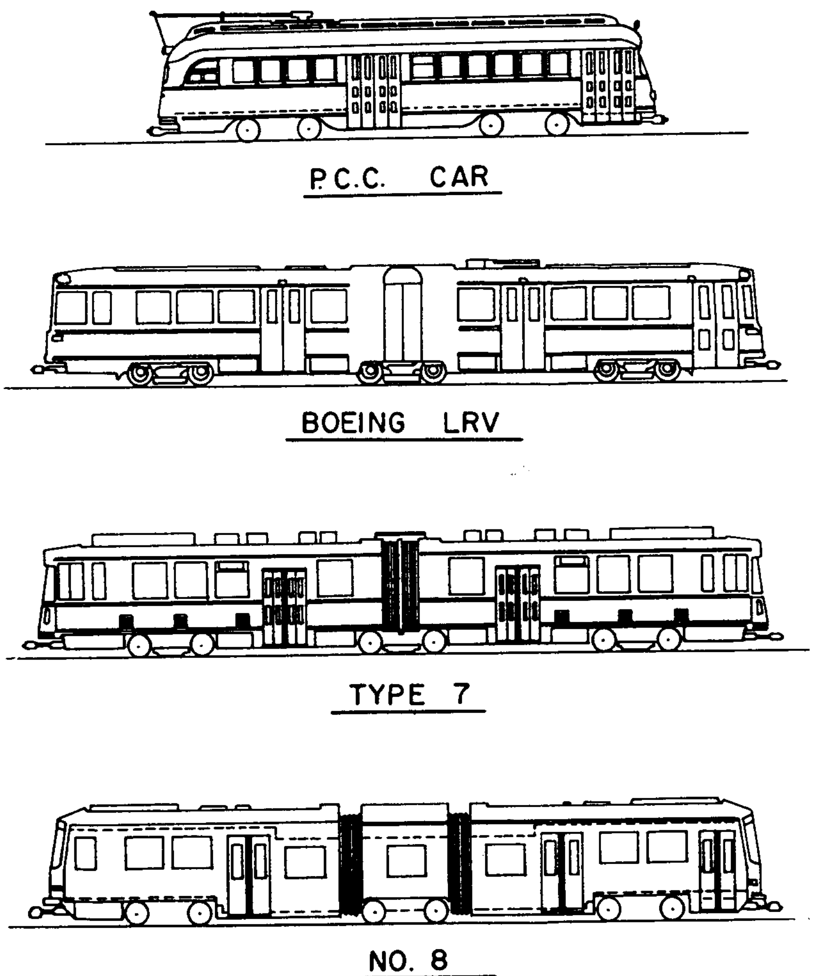


Fig. 3-1
Light Rail Vehicle Types

trolleys date from the late 1940's and have served long beyond their design lives. The ultimate fate of the twelve or so remaining PCC's rests with the undecided future of the Mattapan Line. These trains will require varying levels of alterations if they are to be made accessible for the interim to persons with disabilities.

3.2 Vehicle Requirements

The Boeing Light Rail Vehicles (referred to as "Boeings") were introduced to the system in the mid 1970's to replace the venerable PCC's. These trains have been problematic with respect to reliability over the years and are rapidly approaching the end of their useful lives. Of the approximately 75 Boeings now in service, about 55 of them will undergo a major overhaul in the near future to extend their operational lives. The plan is to retire these vehicles as the newer Low Floor Vehicles become operational and/or if additional Type 7's are acquired. One option considered was to operate Boeings on the Mattapan Line as replacements for the PCC's.

The Type 7 Light Rail Vehicles (referred to as Type 7 LRV's) started to enter service in 1986. The vehicle design is very similar to the Boeing LRV's, however major refinements and improvements were incorporated. The Boeings and Type 7's cannot operate together in one consist. One of the visible differences between the two vehicles is that the Boeings have plug doors whereas the Type 7's have bi-folding doors. Modifications to the bottom door hardware of the Type 7's will be required to ensure proper clearance over the new raised platforms.

The Authority is currently in the process of acquiring at least 100 new Light Rail Vehicles, identified as Type 8 Low Floor Vehicles (LFV). The Low Floor technology will enable these vehicles to be accessible to persons with disabilities. The contract to build the new vehicles was recently awarded by the Authority. Vehicle prototypes are expected to arrive in 1997, with the delivery of production models by 1999. All one hundred should be received within a year or so. Each of the LFV middle doors will be equipped with a deployable ramp system (or bridge plate) which, when deployed, will create an accessible path of travel between the new raised station platforms and the train. The maximum slope of this ramp is 1:6 for a maximum rise of 6" (ADA). The train interiors will be accessible as well. These trains will be dimensionally similar to the Type 7 Vehicles, however they will have a double-articulated mid-section and slightly altered truck spacing. The LFV will be able to operate in consist with the Type 7 vehicles. This will be necessary if the Authority plans to comply with the ADA requirement that at least one car per train (consist) be accessible. The LFV operational characteristics should be similar to the Type 7 as well. The Authority's past experience indicates that the delivered vehicle could deviate to some degree from the specifications. Minor adjustments to track geometry and/or tunnel structure throughout the system could be required if the LFV static or dynamic clearance envelope varies considerably, and from it is assumed that the manufacturer is aware that significant deviations are not possible.

3.2.2 The Low Floor Vehicles

The new Low Floor Vehicles (LFV) will be designed to be operationally compatible with the Type 7 vehicles. As they enter service, they will be formed into consists with Type 7's to maximize the MBTA's compliance with the ADA's "one accessible car per train" rule. They will not be compatible with the Boeing cars which they will eventually replace. With two or three car consists, it is not operationally feasible to dictate the arrangement of each consist. Consists which reverse direction, at North Station for example, will have a different car order leaving than arriving. Also, as consists are broken down for routine inspection and maintenance, it would be very difficult to "rebuild" consists in a uniform configuration.

The Low Floor Vehicles will be equipped with a deployable ramp at each of the middle doors. The ramp will be stowed beneath the train's low floor and will be visible only when it is deployed. If the ramp is not deployed, passengers will board at the middle doors and step up approximately 6". While the middle section of the LFV will be "low floor", the vehicle ends, at the operator locations, will be at the same height as with the Type 7 vehicles. The front train doors will therefore not be accessible. The deployable ramps will operate on demand only. A button will be located to the side of each middle door. If the button is activated either from the platform or on the train, the driver will then "unlock" or "enable" the ramp, allowing for it to deploy automatically. Under the planned system, the driver will not be able to "enable" just a single door, but both side doors simultaneously. Retraction of the ramps will be fully controlled by the driver. The driver will perform all functions from his seat.

3.2.3 LFV Access Ramps

When the ramp is activated, it will automatically extend out approximately 18" from the train and touch down on the platform. (See ***Fig. 3-2***). Once fully deployed, the ramp will assist in creating an accessible path of travel between the platform and the train. A person in a wheelchair will require a four foot square area at the bottom of the ramp in which to maneuver. This area cannot be occupied by any other platform element including light poles, benches, or signage. Of

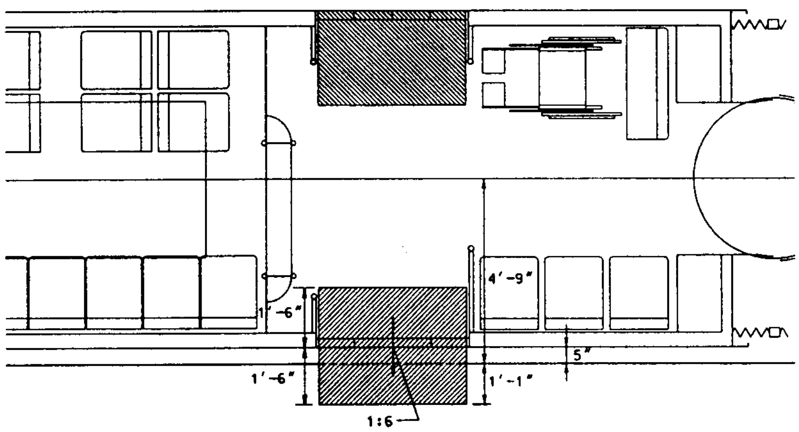


Fig. 3-2
LFV Ramp (Plan View)

equal importance, the area must be approximately 6" below the train floor and not on a slope. Non-wheelchair passengers may have to step out of the train onto a 5% slope. This scenario occurs at stations with inadequate platform lengths for a three-car consist. At certain stopping locations, one of the train doors may open in front of the 5% ramp which connects the raised portion of platform to the lower (existing) surface. Passengers would therefore have to step from the train onto the sloped surface. The MBTA has accepted this scenario as long as the handicapped accessible doors do not open onto a ramp/slope. At many stations, various conditions exist which may make it difficult for the ramps to be accessible. Two options exist: either the obstruction must be moved, or the accessible door must be aligned to miss it. Various approaches are used at each station and are discussed in more detail under the station write-ups. In general, it will be necessary to designate consist stopping locations at many stations to provide accessibility. One of the worst case scenarios for this system would be for a ramp to be deployed in front of an obstacle. It is conceivable that a wheelchair could get stuck between the ramp and the obstacle, creating a significant operational and safety dilemma.

3.2.4 Three-Car Consists

As previously discussed, three-car consists are presently operated only on the D- line. To permit capacity increases in the future, three-car operation will be desirable systemwide. Conversion to three-car operations is dependent on several system improvements. At a significant percentage of stations, existing station platforms will have to be lengthened. At several stations, track crossovers will have to be relocated to facilitate station platform boardings. It is important to keep in mind that three-car consists can only operate on lines where all station platforms are of adequate length. Obviously, where length deficiencies exist, lengthening may trigger full station accessibility compliance. During the most recent traction power upgrade project on the Green Line, the power requirements for the longer trains were provided.

At several stations, existing site constraints will make it very difficult for a three-car consist to be accessible unless special provisions are made. This is discussed in more detail under the individual stations (Boston College, Lechmere, Cleveland Circle).

At Subway stations, it is common for more than one consist to be stopped at the platform simultaneously. Longer consists will impact operations at these stations.

Various operational options to be considered include: limiting ramp deployment to only one door, requiring certain consists to double stop if ramp deployment is necessary, or dictating consist arrangement.

3.2.5 Train-Platform Clearances

The required horizontal and vertical positioning of the proposed raised platform edge is based on several critical elements.

1. Since the Type 7 and Boeing vehicles will remain in operation for the foreseeable future alongside the LFV, clearance must be provided for all three vehicles. (See ***Figs. 3-3*** and ***3-4***). On tangent track, all three train types have an almost identical clearance envelope. On curves however, the envelope varies considerably.

2. The platform height must facilitate usage of the deployable access ramp on the LFV. Given the train low floor elevation and the ADA requirements with respect to vehicle access ramp slopes, the platform height is fixed.

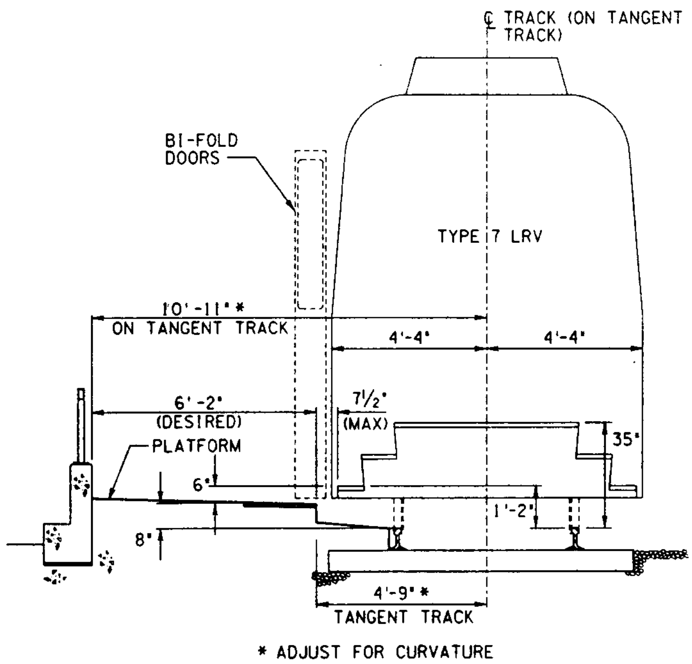


Fig. 3-3
Type 7 LRV at Raised Platform

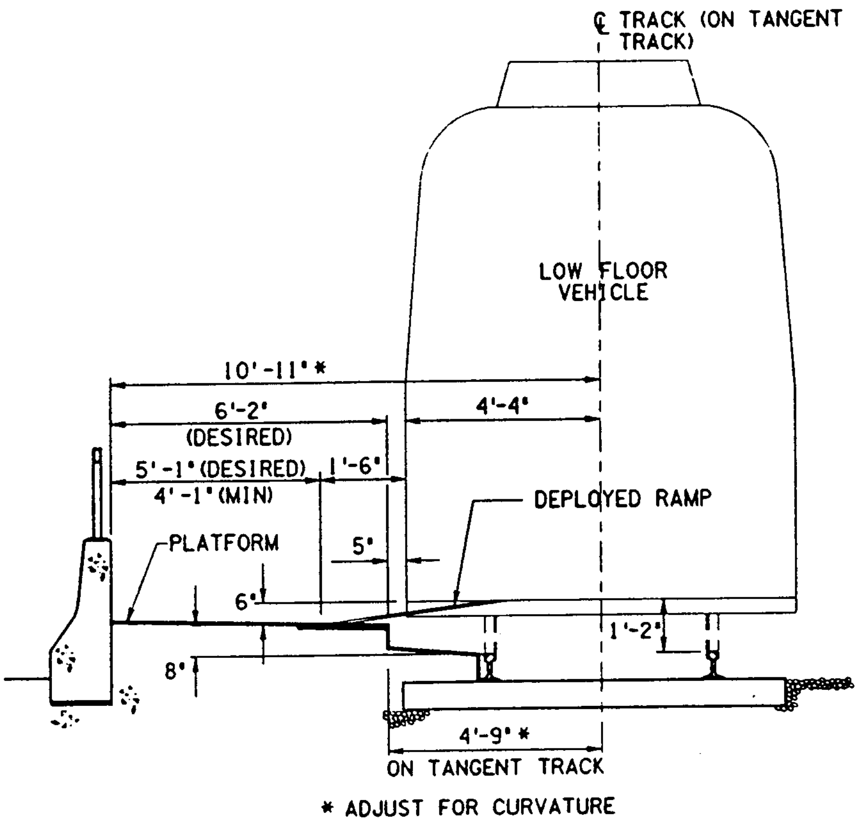


Fig. 3-4
LFV at Raised Platform

3. On curves, the Boeings and Type 7's dictate clearance to the platform. Inside the curve and the LFV dictate clearance to the platforms outside of a curve.

4. The platform height must not interfere with the train door operations. The Type 7 LRV's have bi-folding doors which require additional clearance.

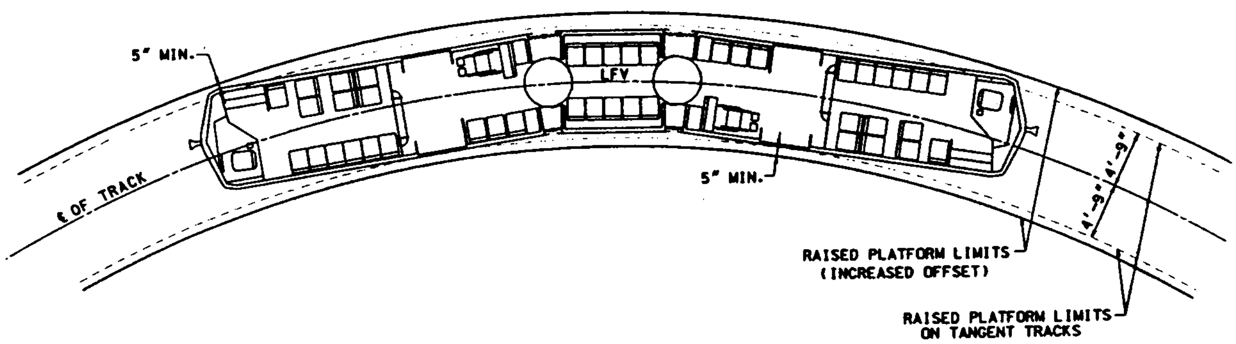


Fig. 3-5
Train Clearances on Curved Track

5. The horizontal offset must be adjusted to account for train clearances on curves. (See ***Fig. 3-5***).

3.2.6 Clearances on Curves

A significant number of Green Line stations are located along sections of curved track or at track crossovers. These situations will result in significant adjustments to clearance requirements given the accessibility approach which requires the raising of Station platforms. As a Light Rail Vehicle traverses a specific curve, the articulated car body clearance envelope varies significantly. The new raised platform edge must be situated accordingly. Under the system's existing configuration, curve clearance constraints do not exist since the train body can pass above the platforms which are typically at or slightly above rail elevation. Raising the platforms to 8" above top of rail will change this condition. Depending on the curve-to-platform relationship, the increased platform edge offsets will be governed by either the front of the vehicle or the middle of the vehicle. Furthermore, since the new LFV's are double articulated with a different pivot spacing, the required offsets will be different from that of the existing fleet.

The MBTA has analyzed the necessary clearance requirements based on specific curvatures and vehicle types. A computer program has been developed which will determine the required platform offsets for each type of vehicle as well as the resultant gaps at both the front and middle train doors. Further information on this is presented in the Appendix.

On several curves, the required offset will result in large gaps between the platform and the train at either the front or middle train doors. Although the minimum gap will always be about 5", on certain curves it can increase to over two feet. Although the offset from the track centerline typically will not exceed 5'-6", the overall gap width is significantly increased due to the train body configuration on curves. The raised platform configuration accommodates the fact that riders may not always be stepping on the platform as they board or deboard the train. With the deployable access ramp however, the offset is constrained. Given the 18" length of the ramp extension, there will be situations where the train-platform gap will be greater, precluding ramp deployment.

Solutions to this dilemma are dealt with on a station by station basis and typically require train stop position and platform configuration adjustments.

The MBTA's intent is to make sure that the low floor doors will be able to stop at locations where the ramp can be properly deployed. Doors located at the high floor ends of the car can load at low level portions of the platform (0" to 2" above top of rail). At terminal stations where there may be severe space and curvature constraints, the inbound trains need only load at one low floor door.

Track curvature may also result in inadequate track center to center spacing and/or wayside clearances at certain locations throughout the system. The exact dynamic clearance envelope of the LFV cannot be firmly established until actual prototype LFV's are delivered and tested. It has been the MBTA's experience in the past that the delivered vehicle clearances can vary from those specified. At certain locations systemwide, adjustments may be required.

3.2.7 Platform Height Considerations

In the MBTA's original feasibility study for Light Rail Accessibility, the recommended accessibility solution was to utilize Low Floor cars in conjunction with platforms raised to match the train floor elevation (14" above top of rail). The problems with clearance requirements along curves as well as the bi-fold door conflicts were not resolved. After the MBTA reviewed this issue further, the decision was made to lower the platforms to 8" above top of rail and utilize a train-borne ramp to bridge the gap. If accessibility is desired, LFV and ramp slope limitations will not permit a platform height of less than 8" above top of rail. Under certain operating conditions, tests have determined that the lower door guides on the Type 7 Bi-fold doors will not always clear the 8" raised platform. To rectify this situation, it will be necessary to cut about 1" to 1-1/2" off the door guides. The plug doors on both the Boeings and the new LFV's are not problematic.

3.3.1 Train and Station Operations

On the Green Line portion of the Light Rail system, the MBTA currently operates a combination of the newer Type 7 vehicles and the older Boeings. Both vehicles operate primarily in single or double car consists. On the D-Line, three-car consists are often run during peak periods. Due to electrical system differences, the Boeings and Type 7 vehicles cannot be linked together into one consist. At the ends of each designated run, the consists reverse direction one of two ways. At most terminal stations, the consists use a loop track. At other locations and under special conditions, the train operators reverse train direction by switching ends.

Aside from the train storage facilities located at the maintenance facilities and line termini, several track sidings are located throughout the system which are used for temporary train layovers during peak periods.

Train control varies throughout the system. On both the D-Line and the central subway, a wayside signal system with track circuits is utilized. Elsewhere in the system, a signal system is not provided. An Automatic Vehicle Identification (AVI) system is in place to relay vehicle locations back to the Operations Control Center (OCC) on High St. AVI detectors are located along the tracks throughout the system. Internal train communications systems also link the trains with the OCC. Trolley priority signals are installed at many cross streets on the surface lines.

Traction power for the Light Rail Vehicles is provided by an overhead catenary system. A trolley wire carrying 600V DC is suspended from catenary poles about fifteen feet above the center of each track. Power enters the trains through the pantograph and leaves through the steel wheels to the tracks. The system includes both aerial and buried feeder cables and negative return cables as well as other distribution equipment.

3.3.2 Operational Assumptions

The preparation of this report and the related design and engineering guidelines have required that a number of assumptions be made, most having to do with train operations. In most cases, the assumptions are based on input received from the Authority. The major assumptions are as follows:

1. All Accessibility work, where feasible, shall incorporate provisions for the future operation of three-car consists.

2. At stations which accommodate multiple consist operations, train operators can be expected to stop the train within five feet of a designated point. Furthermore, a second consist pulling up behind the first consist can be expected to stop two feet clear of the first.

3.4 Clearances

This section of the design manual sets the guidelines for clearances for track in the surface and subway stations and yard areas. These guidelines deal with the horizontal and vertical clearances which must be maintained for the station and track rehabilitation areas. The amount of track which is to be rehabilitated is a small percentage of system track. The track work is limited to stations, roadway crossings and yard areas. At the time of the writing of this manual the Low Floor Vehicles (LFV) or No. 8 cars have not been manufactured and the clearances published here should be verified with the MBTA.

3.4.1 Design Objective

The clearances for the project must provide safe operation for all the transit vehicles which are using the Green Line. This section includes the minimum dimensions for clearance between transit vehicles, and structures and facilities.

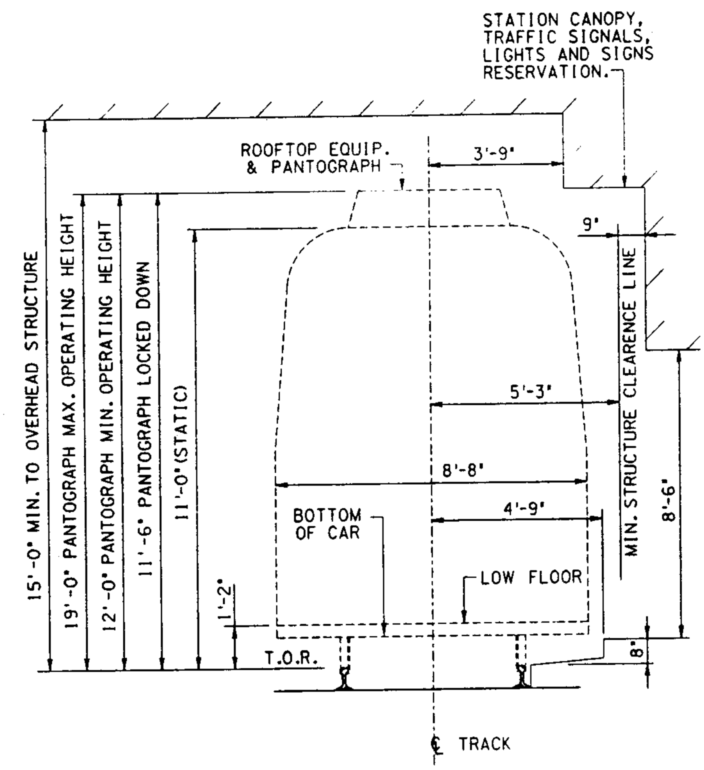


Fig. 3-6
LFV Clearances

Accessibility for the patrons on the platforms and at the track crossings is also a concern of this section. The railbed of the system is on grade with the passenger platform and pedestrians can access the track at many points. Any area reconstructed should allow adequate clearances at fixed objects. The basic dimensions shown in ***Fig. 3-6*** are for a tangent alignment, and additional clearance is required for horizontal curvature and superelevation. Any deviation from the minimum criteria shall be subject to MBTA approval.

The width of the carbody is 8 feet 8 inches over side sheets and is the basis for all clearance calculations. Rub rails project beyond the side sheets giving an overall width of 8 feet 10-1/2 inches at the rub rails. Because of their location the rub rails do not impact platform clearance.

Safety

Safety

The clearance envelope for the transit vehicle must be strictly adhered to for the safe and efficient use of the vehicle and the system. The vehicles should be able to pass through the stations and pass each other at the design speeds. Many clearances are published to allow emergency clearance of transit vehicle operator or man on the track. It should be noted that the MBTA will be operating several types of vehicles on the Green Line after the platforms are reconstructed. The station amenities, signage, fencing, and shelters should be placed well outside of the clearance envelope.

Accessibility

Accessibility

The improvements to track must be done with the requirement that all proposed crossings shall be accessible. Special care should be taken that path of travel does not overrun the clearance envelope of the transit vehicles. At crossings the rail traffic should be controlled and channeled to allow for a clear line of sight for pedestrians and vehicular operations. The platform area must also be made accessible and the limits of encroachment must maintained.

3.4.2 Design Guidelines

Clearances

Clearances

The clearance between dynamic outlines of design vehicles on adjacent tracks shall be a minimum of 6"

1. Track Centers - On tangent tracks, where there are no poles or intertrack fence, the preferred minimum horizontal distance between Green Line track centerlines for new work shall be 10'-0". The track centers shall be increased to the preferred minimum of 13'-0" if catenary poles and/or fence are located between tracks. There are existing locations where track spacing is less than preferred minimum. When practical to do so during reconstruction the clearance should be improved to meet preferred standards. Other site and alignment constraints may limit the amount that track centers can be spread.

2. Side Clearances - The preferred minimum horizontal clearance for the transit vehicle from centerline of track to any face of structure shall be 6'-0". In special cases, a minimum 5'=3" horizontal clearance shall be allowed with MBTA approval. The horizontal clearance at the pantograph is 3'-9". Preferred minimum clearance from centerline of track to a fence on the outside of the track right-of-way is 7'-0", on tangent track.

3. On curves, the minimum track centers and side clearances shall be increased. Clearances shall be increased on the inside of curves by the amount of middle overhang of the dynamic outline of the existing vehicles and on the outside of curves by the end overhang of the LFV's. A computer program, MBTA Green Line Low Floor Car Platform Clearance Locator, has been developed by MBTA to calculate overhangs of the transit vehicles to be used on the system. A description of this computer program is attached in Appendix A.

4. Superelevated Track - Side clearance must be increased 2" per 1" of superelevation, on the inside of a curve. The same adjustment shall be used to increase track centers when the track on the outside of the curve has greater superelevation than the track on

the inside, based on the difference in superelevation. Note that until the deployable ramp design is complete and tested, no superelevation will be permitted at low floor loading areas of stations.

5. Vertical Clearances - The minimum transit vehicle body vertical clearance from top of rail shall be 15'-0" to the overhead structure. The maximum pantograph operating height will be 19'-0". The minimum pantograph operating height will be 12'-0" as shown in ***Fig. 3-6.*** Where there are public grade crossings, or the track is in the street the trolley is normally 18'-6" above top of rail.

6. Platform Clearances - The platforms must be raised 8" above the top of rail. The Low Floor Vehicle would have a 36" bridge plate extending 18" out from the car body. The ramp, when extended will slope at a 6 to 1 slope maximum. The drop from the Low Floor Vehicle to the platform will be a maximum of 6". The minimum clearance from the end of the extended ramp to any obstruction on the platform is 5'-1" as shown in ***Fig. 2-66*** (Section 2.4.4.). (This includes 1" for tolerance in car position) This clearance area will allow a wheelchair to turn after clearing the ramps. This clearance can be achieved by locating the train stop zone to allow the ramps to deploy in clear areas. Therefore, the preferred minimum width of platform shall be 6'-2" and a minimum of 5'-2" could be used with MBTA approval.

   To allow the existing vehicles to access the station the platform edge must be 4'-9" from the centerline of track at tangent sections as indicated in ***Figs. 3-7*** and ***3-8*** for Low Floor Vehicle and Type 7 car, respectively. The clearance from platform edge to the centerline of track on curved sections shall be calculated using the MBTA computer program. ***Figs. 3-9*** to ***3-12*** present the concept of platform offset on curvatures for both Low Floor Vehicle and Type 7 car on a 180' radius curve. The location of the platform edge on the outside of curves is governed by the new No. 8 cars but the platform edge on the inside of curves is governed by the Type 7 car. An intermediate step is required at the platform edge, this will allow passengers to use the LRV's front door and use the doors which are recessed and have a large gap to the platform edge. The area between the top of rail and platform edge will slope on a 12:1 slope. The reveal at the edge of platform will be 6". Note that track curvature at the low floor loading area should be limited so that the foot of the deployed ramp is not less than 2" into the platform.

7. Finalized Clearance Requirements - All clearance discussions in this report are based on existing vehicles and the LFV as specified. As car design progresses some limited changes may occur. New information will be provided by the Authority when available.

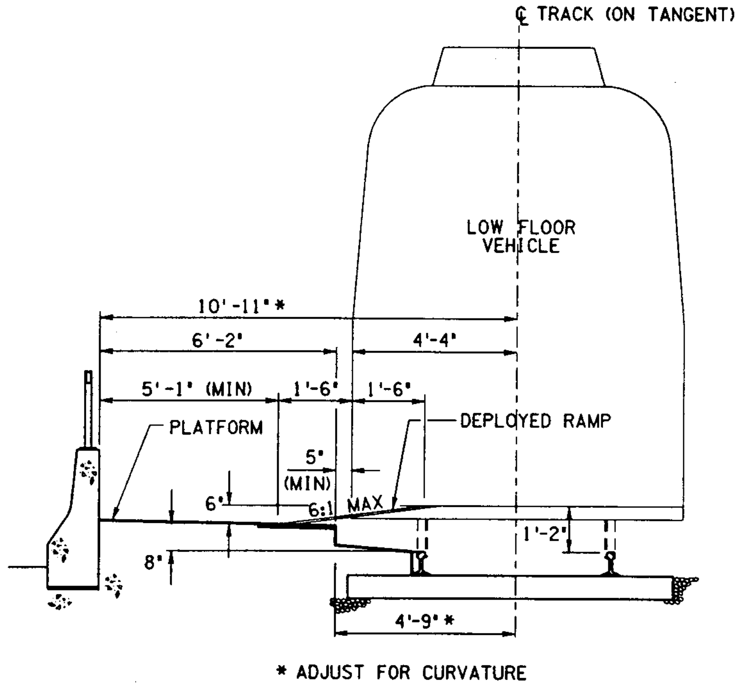


Fig. 3-7 *LFV at Raised Platform*

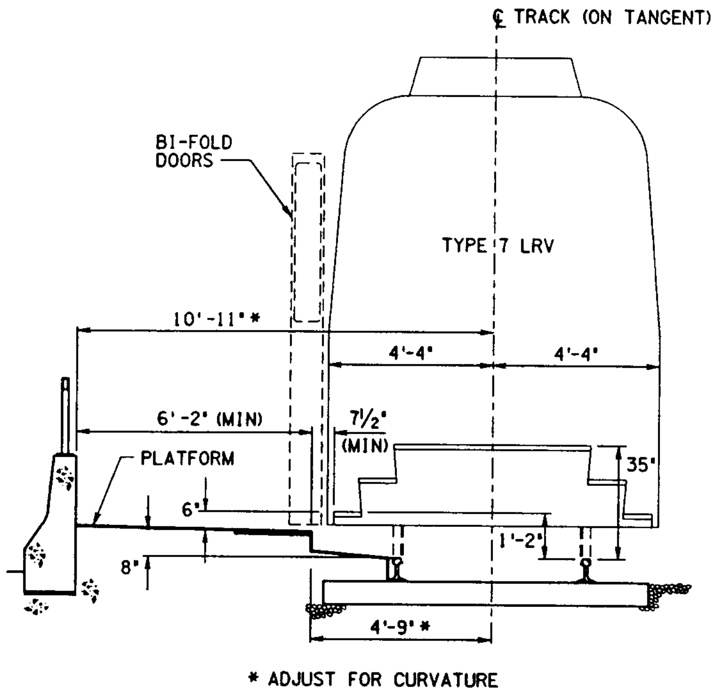


Fig. 3-8 *Type 7 LRV at Raised Platform*

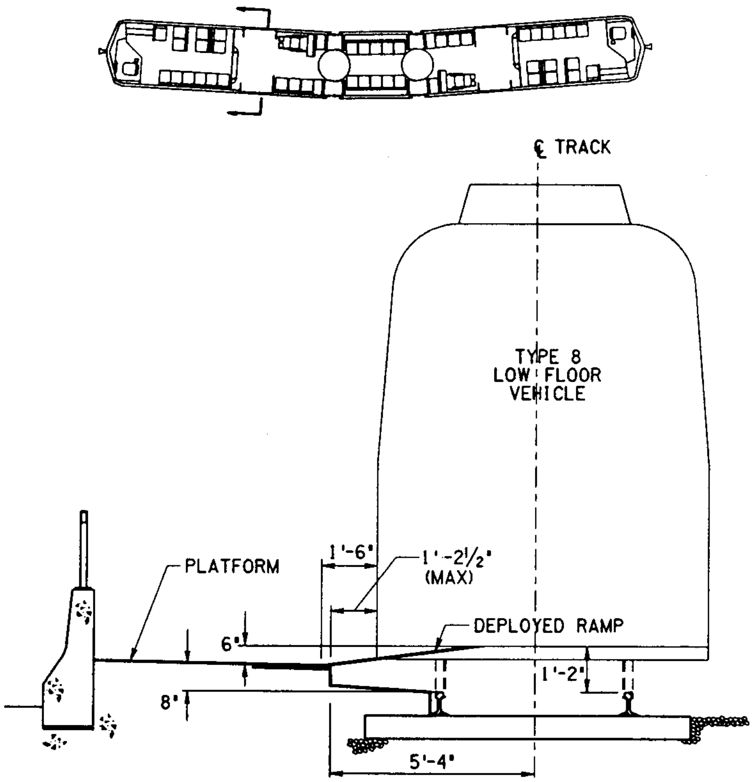


Fig. 3-9 *LFV at Raised Platform on Outside of Curve (R=180')*

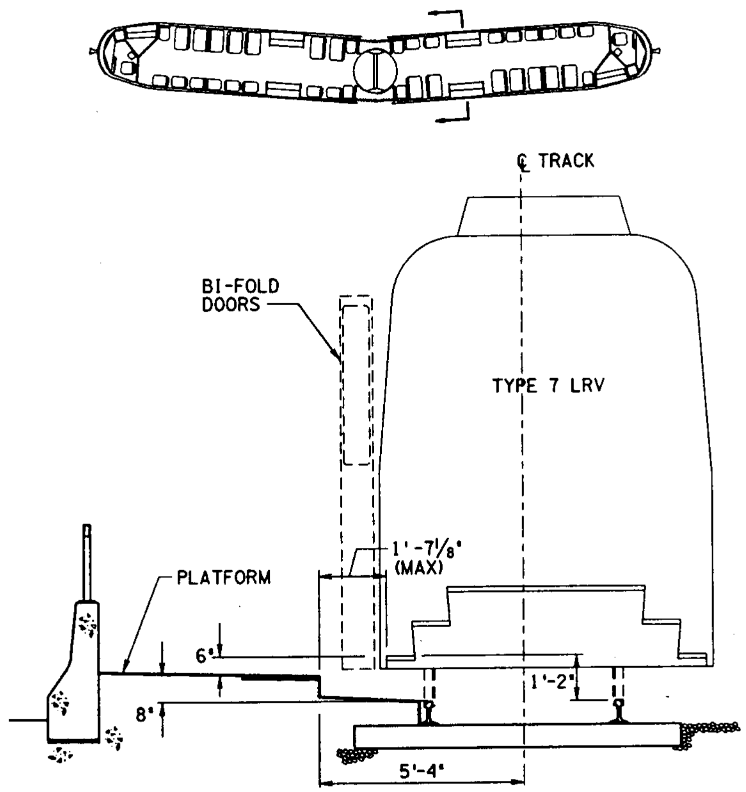


Fig. 3-10 *Type 7 LRV at Raised Platform on Outside of Curve*

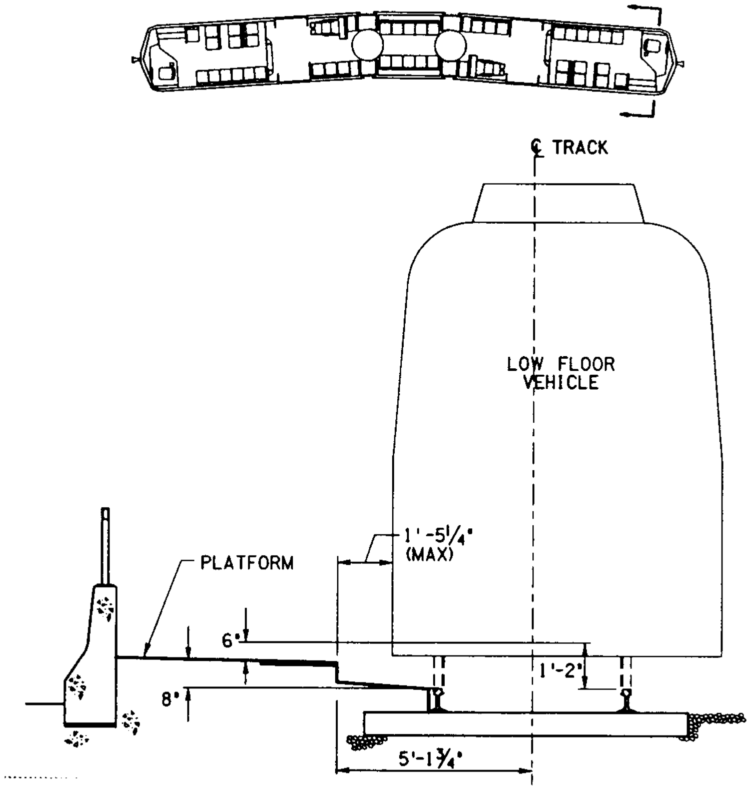


Fig. 3-11 *LFV at Raised Platform on Inside of Curve (R=180')*

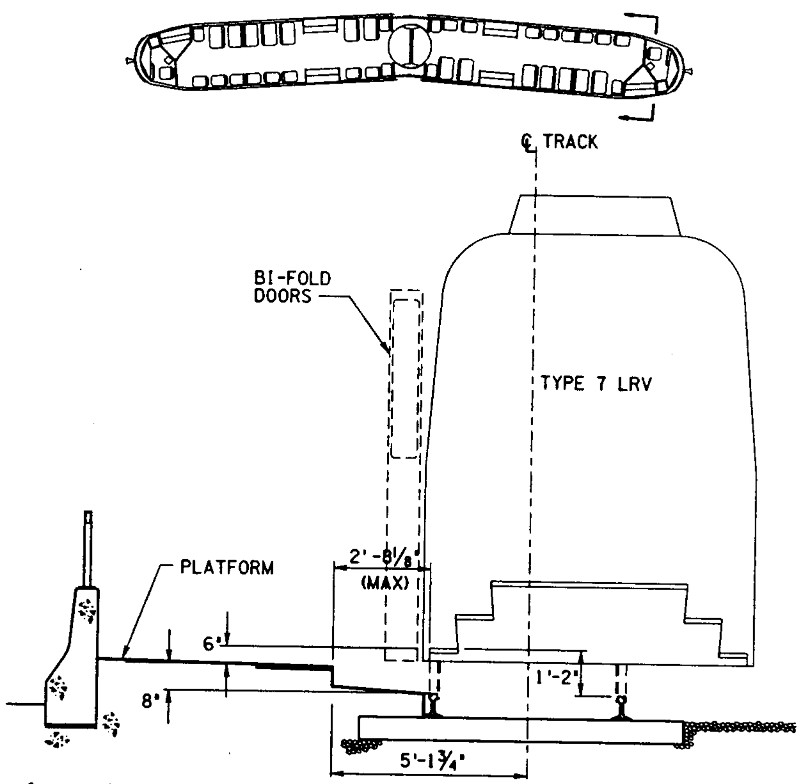


Fig. 3-12 *Type 7 LRV at Raised Platform on Inside of Curve (R=180')*

3.5 Track Work

This section will discuss the design of tracks for the improvement project. The main objective is to provide guidelines for any trackwork which will be involved in the Green Line station improvements. The new or modified trackwork should be maintainable and compatible with the new and existing track/vehicle system. There must be close coordination of the design of trackwork, stations, related roadway structures, and the traction power and signal systems. The requirements addressed hereinafter look at the most frequently used standards. The MBTA standard drawings or A.R.E.A. manual will govern any subjects not covered in this section.

Durability and Maintainability

The design of the track layout, the methods of construction, and the materials all contribute to the durability and maintainability of the rail system. The horizontal curves, special trackwork, grades and operating speeds all have an effect on the durability and maintainability of the track and railbed, and the vehicles using it. The methods of construction and the materials used should match existing standards to ease in the maintenance and operation after trackwork is completed.

Durability and Maintainability

Compatibility

The track system must be compatible with existing and new Green Line vehicles. Standards for curvature, flangeways, special trackwork details and gage, on the Green Line are based on the wheel profile, wheel spacing, axle load and other characteristics of the light rail vehicle. MBTA Green Line standards may deviate from A.R.E.A. and heavy rail transit standards. Where Green Line track is in paving or street reservation, compatibility with roadway contraints and design standards may be necessary.

Compatibility

3.5.1 Geometry

Design Speeds

Minimum Design Speed (Desired) - 25 mph

Design Speeds

The design speed on curves shall be determined by considering horizontal and vertical geometry of the track. This includes factors such as radius of curvature, superelevation, and grades. Many other factors such as proximity to station stops, street crosswalks, operational criteria, signals and other restrictions will also affect the design speed and design criteria.

Horizontal Alignment

Horizontal Alignment

1. Horizontal Curves

   Curves intensify the problem of maintaining line, gage and cross level. The forces applied to the track structure by the vehicle on curves reduce rail life and increase tie wear. Train speeds and safety are directly related to the horizontal radius of curvature and superelevation of the rails.

2. Minimum Horizontal curve Radius - 50′

   The preferred minimum radius for mainline tracks is 200′. The preferred minimum radius within a station area where low floor loading occurs is 400′.

   On curve sections, the outside rail of the track shall be raised to attain superelevation. The raise should be achieved uniformly throughout the length of the transition. Spiral curves shall be used as transitions to connect tangents to circular curves where practical.

   Design of track horizontal alignment shall use the following definitions: (See ***Figs. 3-13*** and ***3-14*** for details.)

R	=	Radius of curvature (in feet)
Da	=	Degree of curvature by arc definition
	=	$18{,}000/\pi R$
I	=	Total deflection angle of total curve, including spirals and compound curve segments

   The preferred minimum length of circular curve for mainline track shall be 50′.

3. Tangents

The preferred minimum length of tangent between curves is 50′. The minimum tangent length shall be 10′ with approval by the MBTA.

4. Spirals

Spirals shall be used to connect all curves to tangents, only when practical. There are numerous right-of-way constraints that prevent use of spirals and/or superelevation.

Spiral lengths shall equal or exceed the values computed by the following formula:

$$Ls = V(Ea)$$

Where, Ls = desired length of spiral curve, feet, and
Ea = actual superelevation, inches, and
V = design speed in MPH. Maximum runoff of superelevation is 1″ in 30′ feet (max. as V=30 MPH).

The preferred length of spiral shall not be less than 50′. In special cases, a shorter length may be used with approval of the MBTA. In stations where no actual superelevation is introduced into the curve, a spiral may be used if practical. The formulas for the determination of spiral curve data are shown in ***Figs. 3-13*** and ***3-14***.

For multi-track layout, where two or more tracks follow the same general alignment and the distance between track centers in the circular curve is the same as that in the adjoining tangents, the tracks shall be placed on parallel spirals. If the distance between track centers in the circular curves is different from that in adjoining tangents, each spiral's geometry shall be defined individually.

4. Superelevation

The superelevation is divided into the following elements:

$$Ee = Ea + Eu$$

Where, Ee = total amount of superelevation required for equilibrium, inches,
Ea = actual superelevation to be construct ed, inches, and
Eu = unbalanced superelevation, inches.

The maximum actual superelevation (Ea) shall be 6" with a maximum unbalanced superelevation (Eu) of 3". When track is in paving, including grade crossings, the maximum (Ea) is 1-1/2". Superelevation shall be constant through circular curves and accomplished by maintaining the top of the inner rail at the top of rail profile, while raising the outer rail by the required superelevation. Transition shall be linear throughout the length of the spiral with a maximum run-off of 1" in 30'.

Until the LFV deployable ramp design is finalized and tested, assume no superelevation within the low floor loading area of a station platform.

The total amount of superelevation, Ee, shall be determined using the following equations:

$$Ee = \frac{4.011\ V^2}{R}$$

Where, V = design speed through the curve, mph, and
R = radius of circular curve, feet.

or

$$Ee = 0.0007\ V^2 Da$$

Where, Da = degree of curve, degrees.

In addition, the superelevation should be calculated for each individual curve and should be determined by considering the train speed and curve location as well.

There are locations where it is desireable to have superelevation but alignment constraints prevent use of spirals, "Cheater Sprirals" may be used. Superelevation (no more than 3") is introduced in the tangent at the ends of the curve. If necessary half of the superelevation can be continued past the point of curvature into the circular curve, and in extreme situation, all of it may be within the circular curve. The same technique may be used on curves and sprials when the spiral is too short for the desired superelevation. Use of these procedures must be approved by the Authority.

Vertical Alignment

Vertical Alignment

1. Grades - Mainline, Stations and Yards

   The profile grade line is defined as the top of the low rail.

   Between stations, the preferred maximum track grade for new trackwork shall be 5.0 percent. In station areas the preferred maximum track grade shall be 2.0 percent. At most existing stations, existing grades will control the design.

2. Vertical Curves

   Grades shall be connected by parabolic curves. The length of a vertical curve is determined by the gradients to be connected and design speed. The preferred minimum length of the parabolic vertical curves shall be 50'. Any deviation from the above criteria must be approved by the MBTA.

   The minimum length of vertical curve is determined by the following formula:

   L = 1.5V2D

   V = speed in mph
   D = algebraic difference in grades expressed as a decimal

Equivalent radius of vertical curve:
R = 1.5V2

Minimum Radius of vertical curve is 400'

3.5.2 Type of Construction

Green Line transit tracks shall be of tie and ballast construction, using materials compatible with existing tracks. The construction methods shall meet the current guidelines, applicable standards and specifications. All special track work shall conform to Green Line trackwork directive drawings.

3.5.3 Track Materials

Rail

Rail

1. Rail Size currently in use on the Gree Line:

   Bethlehem 128 lb girder section (no longer produced)

   Bethlehem 149 lb girder guard section (no longer produced)

   GGR 118 girder guard section

   115 RE section

   115 RE bolted to 132 RE vertical restraining rail

   Restraining rail or girder guard rail are used on all curves in thesubway less than 1000′ radius, and on all curves on surface lines less than an 800′ radius, unless otherwise directed by the Authority.

2. Type of Rail

   Control-Cooled Carbon Steel Rail, 115 RE and 132 Re sections conform to current AREA "Specifications for Steel Rails" as set forth in the "Manual of Recommended Practice" shall be used on all transit track. Curves shall be analyzed with respect to radius, operating speed and unbalanced superelevation to determine where excessive rail wear is expected. Heat treated rail, because of its ability to withstand heavy pressures and abrasion, shall be used on curves where excessive rail wear can be anticipated.

3. Method of Joining Rail

Continuous welded rail shall be utilized both to minimize maintenance and control noise and vibration. All running rail shall be continuously shop welded into the longest lengths feasible for transportation and installation. All shop welding of rail shall be governed by the latest "Specifications for Fabrication of Continuous Welded Rail" as set forth in the AREA "Manual of Recommended Practice." Field welds shall be used to join the lengths of shop welded rail.

Due to constraints on transporting Continuous Welded Rail R strings in the subway, all rail is field welded by the thermite process. For track to be laid in reservation or in paving the string shall be field welded on or near the site.

Continuously welded rail shall be used throughout the system, except in the following situations, where bolted joints are recommended; except as otherwise directed by the Authority

- To join switch rails with closure rails.
- To join rail sat insulated joints.
- To join rail ends with crossing and turnout frogs.
- To join rails with stock rails of turnouts.

4. Rail Fasteners

Resilient rail fasteners shall be designed to provide vertical and lateral stability to the rail and restrain the rail from movement in the longitudinal direction. Rail fasteners shall provide electrical isolation for continuous welded rail, on concrete ties or in direct fixation track on concrete slabs.

Ties

Ties

Most of the existing track is on timber ties with concrete ties only on Commonwealth Ave and Mattapan lines. All special trackwork is on timber ties. Timber ties shall be spaced 24″ center-to-center. New timber ties shall be 7″ x 9″ x 8′-6″. Concrete ties shall be spaced 30″ center-to-center.

Ballast

Ballast

Ballast shall be placed as shown on the Trackwork Directive Drawings.

The depth of ballast shall be 12″ (minimum) under the bottom of tie at the low rail for concrete ties and wood ties. The top of ballast shall be parallel to the top of rail. Ties shall be embedded in ballast to within 1″ of the top of tie.

Ballast shall conform to AREA specifications, Chapter 1, part 2, and shall be graded in accordance with Size No. 4 specified in Subsection 4(a).

At grade crossings and special track install a 5″ bituminous concrete underlayment below the ballast. The preferred depth of ballast is 12″; the minimum is 8″. When it is not practical to install bituminous concrete geotextile filter fabric is used instead.

Special Trackwork

Special Trackwork

All tee rail special trackwork shall be heat treated and conform to the latest specifications of the AREA "Portfolio of Trackwork Plans". Girder rail type special work shall conform to MBTA standard specifications and plans. All girder type special trackwork now in use is made up of manganese steel casting. Manganese steel frogs are also used with all tee rail special trackwork.

Special trackwork shall be located on tangent track and on a constant profile grade.

Track Gauge and Tolerances

Track Gauge and Tolerances

1. Gauge

   The track gauge shall be measured between the inner sides of the heads of the two rails at a distance 5/8" below the top of the rails. The transit track gauge shall be 4' 8-1/2" on tangent and on all curves without restraining rail or girder guard rail.

On curves with restraining rail or girder guard rail, and all special trackwork, the gage varies with type of rail, flangeway, and radius. The primary intent of gage widening on curves is to reduce rail wear. On special trackwork gage widening is done to reduce rail wear and to protect points of frogs and switch points from flange contact. See Authority standards and directive drawings for detailed information for trackwork design.

2. Tolerances

Tolerances must be established and met to achieve high quality track. The track construction tolerances are as follows:

Gauge Variation	±1/8"
Cross Level and Superelevation Variation	±1/8"
Vertical Track Alignment:	
Total Deviation	±1/4"
Variation in 31' chord	±1/8"
Horizontal Track Alignment:	
Total Deviation	±1/4"
Variation in 31' chord	±1/8"

The total deviation is measured between calculated and actual alignment at any position in the track system. Greater deviations from design may be allowed in order to achieve a smooth profile and horizontal alignment with approval of the Authority.

Procurement Standards & Specifications

Procurement Standards and Specifications

The specifications for tee rail, ties and other track material used on the Green Line are covered in detail by MBTA Commuter Rail, and AREA design standards, specifications, and standard plans. Tee rail special trackwork, girder rail, and girder rail type special trackwork typical drawings and specifications are furnished by the Authority.

Trackwork materials may be purchased by the Authority for installation by the Contractor, or may be purchased and installed by the Contractor.

SPIRAL TRANSITION CURVE

L_s = LENGTH OF SPIRAL

θ_s = SPIRAL ANGLE = $\frac{L_s D_c}{200}$ (CHORD DEFINITION) = $\frac{L_s D_a}{200}$ (ARC DEFINITION)

$$X = L_s \left(1 - \frac{\delta_s^2}{10} + \frac{\delta_s^4}{216} - \frac{\delta_s^6}{9360} + \frac{\delta_s^8}{685,440}\right)$$

$$Y = L_s \left(\frac{\delta_s}{3} - \frac{\delta_s^3}{42} + \frac{\delta_s^5}{1320} - \frac{\delta_s^7}{75,600} + \frac{\delta_s^9}{6,894,720}\right)$$

$P = Y - R\,(1 - \cos\theta_s)$

$K = X - R \sin\theta_s$

T_s = TANGENT LENGTH FROM T.S. TO MAIN P.I. (EQUAL SPIRAL LENGTHS) = $(R + P)\tan\frac{I}{2} + K$

$T_{s1} = T_I + K + \frac{P_2 - P_1 \cos I}{\sin I}$

(UNEQUAL SPIRAL LENGTHS)

$T_{s2} = T_I + K + \frac{P_1 - P_2 \cos I}{\sin I}$

$ST = \frac{Y}{\sin\theta_s}$

$LT = X - \frac{Y}{\tan\theta_s}$

$LC = \sqrt{X^2 + Y^2}$

E_s = EXTERNAL DISTANCE FROM MAIN P.I. = $\frac{(T_s - K)}{\sin\frac{I}{2}} - R$

Δ = CENTER ANGLE OF CIRCULAR CURVE

δ_s = θ_s EXPRESSED IN RADIANS

D_c, θ_s, Δ & I ARE IN DEGREES

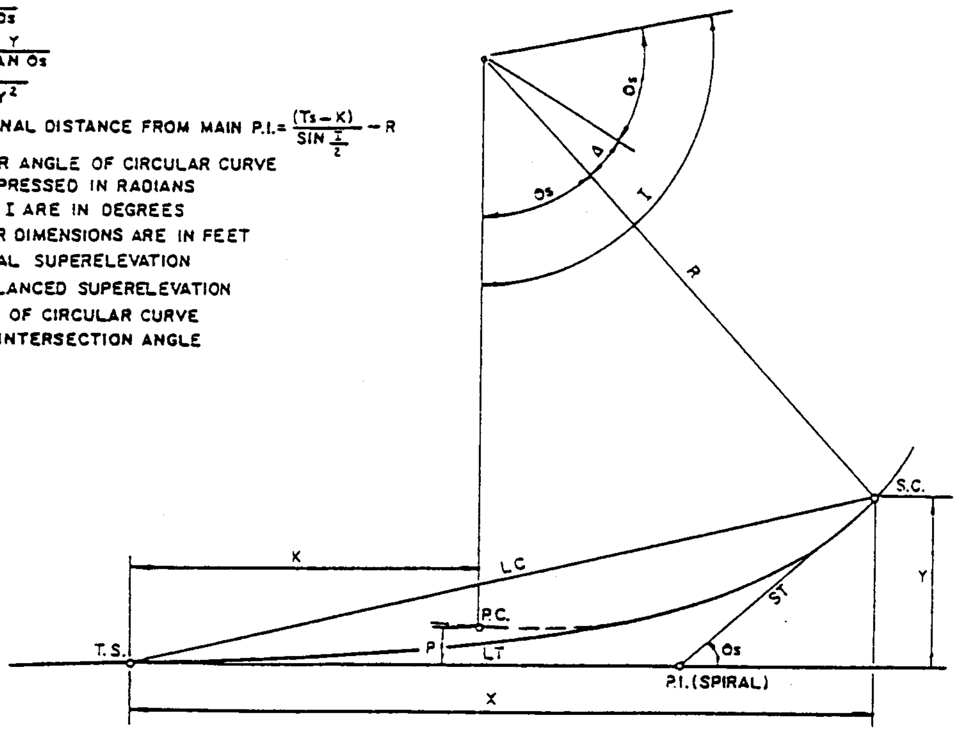
ALL OTHER DIMENSIONS ARE IN FEET

E_a = ACTUAL SUPERELEVATION

E_u = UNBALANCED SUPERELEVATION

R = RADIUS OF CIRCULAR CURVE

I = TOTAL INTERSECTION ANGLE



SUPERELEVATION

ACTUAL SUPERELEVATION (E_a) WILL BE ATTAINED AND REMOVED LINEARLY THROUGHOUT THE FULL LENGTH OF THE SPIRAL TRANSITION CURVE

Fig. 3-13
Horizontal Curves: Spiral Transition Curves
(Ref: MBTA Southwest Corridor Project, "Engineering Design Manual", Fig. II-D)

CIRCULAR CURVES

I = TOTAL INTERSECTION ANGLE

Δ = CENTRAL ANGLE OF CIRCULAR CURVE = $I - 2\theta_s$ (EQUAL SPIRAL LENGTHS)

Δ = CENTRAL ANGLE OF CIRCULAR CURVE = $I - (\theta_{s1} + \theta_{s2})$ (UNEQUAL SPIRAL LENGTHS)

D_c = DEGREE OF CURVE (100 FT. CHORD DEFINITION) = $2 \text{ ARC SIN} \frac{50}{R}$

D_a = DEGREE OF CURVE (ARC DEFINITION) = $\frac{18,000}{\pi R}$

R = RADIUS OF CIRCULAR CURVE

T = TANGENT LENGTH OF CIRCULAR CURVE = $R \tan \frac{\Delta}{2}$

L_c = LENGTH OF CIRCULAR CURVE (CHORD DEFINITION) = $\frac{\Delta}{D_c} \times 100$

L_a = LENGTH OF CIRCULAR CURVE (ARC DEFINITION) = $\frac{\Delta}{180} \pi R$

E = EXTERNAL DISTANCE = $R \text{ EXSEC} \frac{\Delta}{2}$

LM = CHORD LENGTH OF CIRCULAR CURVE = $2R \sin \frac{\Delta}{2}$

M = MIDDLE ORDINATE DISTANCE = $R(1 - \cos \frac{\Delta}{2})$

PC = POINT OF CURVE

PT = POINT OF TANGENCY

TS = TANGENT SPIRAL

SC = SPIRAL CURVE

CS = CURVE SPIRAL

ST = SPIRAL TANGENT

PI = POINT OF INTERSECTION

T_I = TANGENT LENGTH FROM P.C. TO P.I. $T_I = R \tan \frac{I}{2}$

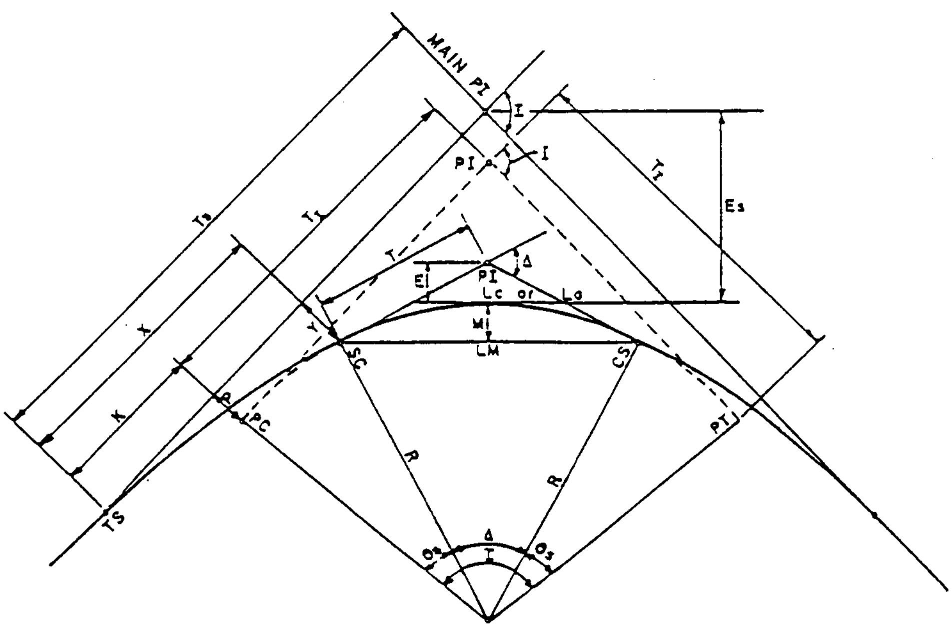


Fig. 3-14
Horizontal Curves: Circular Curves
(Ref: MBTA Southwest Corridor Project, "Engineering Design Manual", Fig. II-E)

3.5 Track Work

3.6 Signal System

Following is a summary of the signal system(s) on the Authority's trolley lines. This summary is provided to identify equipment in place, method of operation and to identify potential impacts to the operating system caused by the proposed station accessibility project.

3.6.1 General

The Green Line can be divided into three areas when discussing signal systems:

1. Central Subway (including Lechmere through to all portals).
2. Highland Branch (Beacon Jct. to Riverside).
3. Surface Lines (Commonwealth Ave., Beacon St., Huntington Ave.).

At the two stations, Ashmont and Mattapan, on the "high speed" trolley line branch of the Red Line, there are no impacts associated with construction because there is no signal system.

The Central Subway and Highland Branch ("D" Line) have signal systems. The Surface Lines ("B," "C" and "E" Lines) do not have signal systems with track circuits and associated equipment. They do, however, have some trolley priority and automatic vehicle identification (AVI) equipment. For the purposes of this document, the AVI and trolley priority (for use with automobile traffic signals) equipment will be considered as signaling functions. In some locations, switching/route selection is accomplished with AVI equipment.

The Central Subway and Highland Branch signal systems consist of color light signals controlled by relay logic. The Central Subway operates using single rail track circuits, while the Highland Branch ("D" Line) primarily utilizes double rail track circuits. Both signal areas utilize a 25–cycle 600 VAC signal feeder system for the automatic signal territory. At interlocking (switching) areas, 60 Hz 120 VAC power is used. The vast majority of cabling is aerially routed rather than underground. In the Central Subway tunnels, the majority of cables run along the bottom of wire racks on a messenger wire with signal cables strapped to it.

On the Highland Branch, messenger wire is strung along the catenary poles and carries the signal cabling. The only notable exceptions are Reservoir and the Riverside facilities where underground cabling manhole networks are in place. Other than these two locations, cabling is only routed underground locally when dropping down into an equipment case or to a signal device.

"Trolley priority" is installed on the Commonwealth and Huntington Ave. branches. The "trolley priority" interfaces with the City of Boston traffic lights at several locations. This system senses a trolley approaching the station and/or one waiting to depart at a traffic light and may extend the city traffic's light cycle dependent on local traffic conditions.

3.6.2 System Components

Following are typical elements comprising the signal system:

Track Circuits

Track Circuits

Electric circuit that uses rails as a part (conductor) to detect train presence. On the Highland Branch, impedance bonds, mounted between the rails at insulated joint locations, are also used to block AC signal current while conducting negative return current back to the substation.

Signals

Signals

All signals on the Green Line are color light signals. For example: green=proceed, yellow=slow, prepare to stop at next signal, red=stop. There are also several two-light units (Y,R) and interlocking utilize multiple lighting configurations to display signal aspects.

Enclosures/Housings

Enclosures/Housings

Signal equipment and wiring is contained in wooden, sheet metal and cast iron enclosures in a wide variety of shapes and sizes. Some are wall (niche) mounted, primarily in the subway, and many are mounted on foundations along the right–of–way. Also, some signal equipment and/or conduit is affixed to catenary beams.

Cables

Cables

The signal system is dependent on relay logic which is transmitted electrically by cabling. Most of the cable is aerially routed and carries low voltage circuits (120V and under). Underground cables are used to access local devices. Underground cabling via a manhole system is employed at the Reservoir facility. Signal power network consists of cables, ranging from #6 to #4/0 AWG in size, carrying 600 VAC to feed the signal system's local transformers.

Switch Machines

Switch Machines

Routing of trains is facilitated by switching at interlockings. Both automatic (electrically powered) and manual machines are installed to switch the rails and route trains. At several locations, the logic to control/operate these switches is initiated via the AVI system.

AVI

AVI

Automatic Vehicle Identification, installed at several antenna points to record information from passing trains. Primarily a dispatcher's aide, it also serves to provide route selection at several interlocking (switch) locations. AVI is provided throughout the Green Line, including the non– signalled "B," "C" and "E" Lines.

Trolley Priority

Trolley Priority

A system of concrete encased wire loops, pull boxes and pedestal mounted equipment enclosures is installed along the Commonwealth and Huntington Avenue tracks ("B" and "E" Lines).

The loops and detector units sense when a train passes over. This indication is transmitted into the City of Boston traffic signal case which, in turn, communicates with the central computer to influence duration traffic light cycles. In several instances, traffic light cabling is routed under trolley platforms and the streets crossing the tracks.

3.6.3 Construction Impacts

The LRAP project should have little impact on the signal systems currently working on the Green Line. In the Central Subway, most cabling is run aerially and usually through the center of the stations, between platforms. On the Highland Branch, cabling again is run aerially and appears to avoid the potential construction areas. Possible exceptions, where impacts due to construction may arise, include Reservoir and Newton Highlands stations on the Highland Branch.

At Reservoir, there are signal manholes that will require alteration due to the raising of the outbound platform. If the proposed remedy is to simply build up the manhole and raise the cover, significant signal costs should be avoidable.

One possible alternative for construction at Newton Center involves lowering the track elevation by six inches through the platform area. The run–off from this track profile change will probably require some trackwork out to signal locations H41 (inbound) and H48 (outbound). Depending on the method and extent of construction, these signal locations may be protected in place. Some allowance, however, should be considered for temporary signal work or relocation during track construction.

The AVI sites observed should present no construction impact, with the exception of Coolidge Corner. The equipment abutting the platform construction area at Coolidge site may be removed or relocated since it has never been functional.

Trolley priority equipment, concrete encased loops, junction boxes and cables may involve relocation, to a limited extent, at certain surface stations where new rubberized crossings are to be installed. No direct impacts were visible, although some locations are relatively close to proposed roadwork and actual location of trolley priority cables and other traffic light cabling is not defined.

In many areas of the City Boston and Town of Brookline traffic cables are routed under station platforms and street/track crossing areas. This traffic signal cabling situation exits regardless of trolley priority and will require coordination with the Boston Transportation Department or Brookline Public Works Department before construction commences.

As with the possible trackwork construction alternatives (eg. Newton Center), an allowance should be considered for the possible relocation or protect in place work related to trolley priority system elements.

Overall, the signal impacts are minor. With the new platform construction taking place, considerations should be given to providing cable raceways through the station for future signal and communication wiring. The existing Green Line cablenetwork is antiquated and, with signal and communication system upgrades anticipated, provisions for routing cables through station areas during this contract could greatly reduce future construction costs.

At grade crossings which are reconstructed, empty conduit crossing the street and/or tracks, shall be provided if directed by the City or Town Traffic Engineer.

3.7 Traction Power Systems

The MBTA has begun design activities to make all Green Line stations handicap accessible, in accordance with ADA requirements. A large portion of this work will affect the power equipment. This section provides an overview of the power work to be performed in support of this project.

3.7.1 General

Following is a summary of the power system installed on surface lines of the Authority's Green Line. This summary is provided to identify equipment in place, method of operation and to identify potential impacts to the operating system throughout the construction phase of the above-referenced contract.

MBTA streetcars are powered from a trolley wire suspended approximately 14′ to 18′ above the center of the tracks and supported from a series of catenary support poles located between or on both sides of the tracks. The trolley wire is energized with 600Vdc, similar to a third rail system, and is used to power the streetcars. Power enters the streetcar through a pantograph, the adjustable scissor shaped mechanism located on the top of the streetcar, and leaves through the steel wheels to the tracks. The entire overhead configuration of trolley wires, supports and hangers is commonly referred to as a "catenary" system.

3.7.2 System Components

Following are the major equipment components of the catenary system:

Traction Substations

Traction Substations

The catenary receives its power from traction substations which employ transformers and rectifiers to transform 13.8kV alternating current to 600V direct current.

Trolley wire

Trolley Wire

The purpose of trolley wire is to supply power to the streetcar. It is specially designed copper wire, suspended approx-

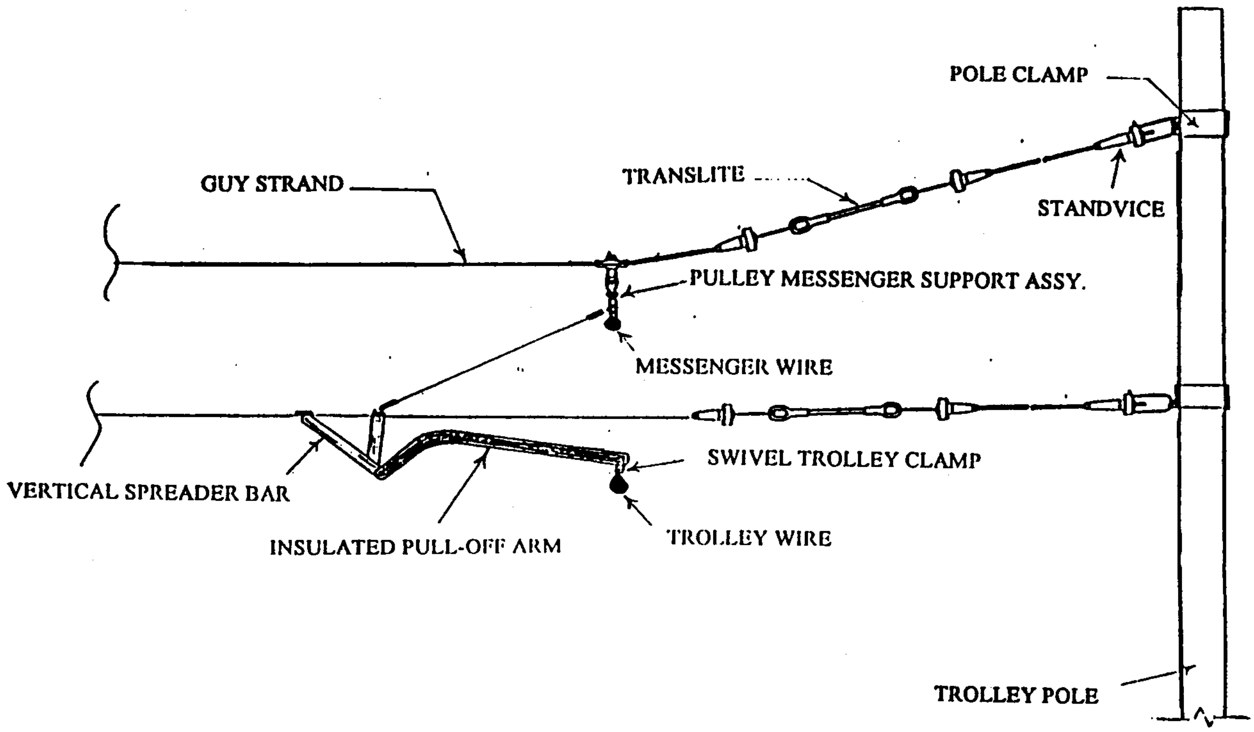


Fig. 3-15
Constant Tension Type Catenary

imately 14′ to 18′ above the center of the tracks, and in constant direct contact with the streetcars' pantograph. Trolley wire supplies power to the streetcars' pantograph where it is distributed for traction power, lighting, air conditioning and heat.

Messenger wire

Messenger wire

The purpose of messenger wire is to provide support for trolley wire and to transmit power efficiently over long distances along the surface route. Messenger wire runs parallel to trolley wire and is suspended in the configuration of a catenary curve 6″ to 30″ above it. At regular intervals, trolley wire is electrically connected to the supplementary wire via special hangers which allow power to be transferred to trolley wire. Messenger cable is used on the Riverside and Beacon St. lines. Other lines use "stitch" construction whereby the trolley is supported at two points by a short insulated cable in an inverted 'V' configuration. The "stitch" is supported by a bracket arm or span wire.

Catenary support poles

Catenary support poles

Trolley poles are located at approximately 100′ intervals between or on each side of the surface tracks and provide support for trolley and messenger wires. Trolley and messenger wires attach to span wires which run between two adjacent trolley poles. Insulators are installed on all wires connected to trolley poles to prevent electrical power from energizing the poles.

Catenary

Catenary

All overhead trolley devices and mechanisms are collectively referred to as the "catenary." Catenary is a complex arrangement of numerous hangers, supports, insulators, brackets, support arms, etc. which are suspended overhead along the streetcar right-of-way and provide traction power for the streetcars. The catenary system is similar to a battery circuit, where the trolley wire is the "positive," the tracks the "negative" and the the streetcar the load.

Feeder cables

Feeder cables

The purpose of feeder cable is to bring electrical power from electrical substations to sections of trolley wire. These 600V feeder cables are run underground in cable ducts and manholes, or are supported by the poles. When feeder cables leave the ground at various poles, run up poles where they pass through power switches and attach to the catenary system.

Supplemental conductors

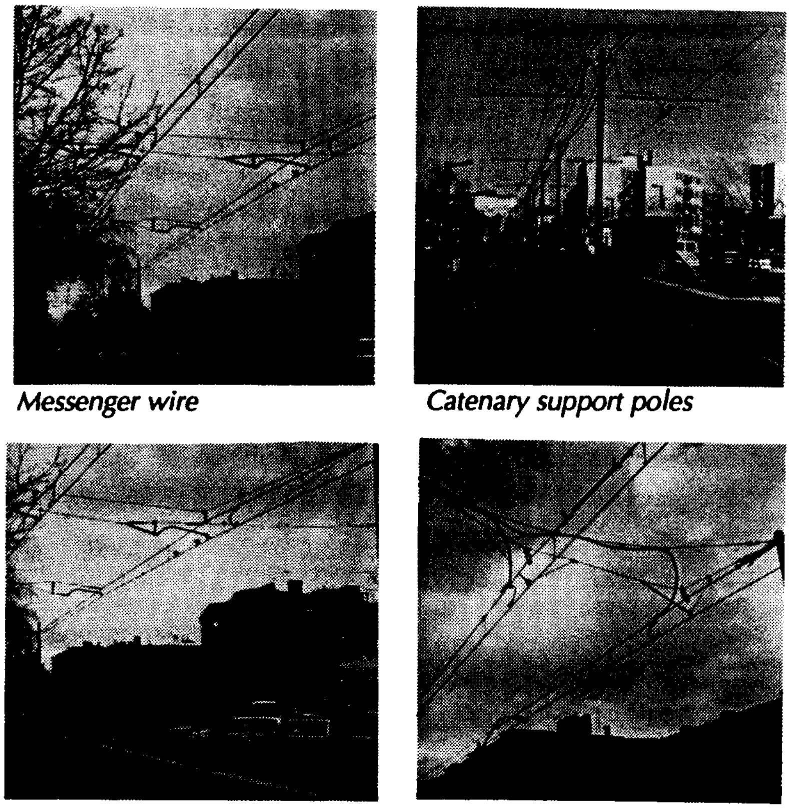
Supplemental conductors

These cables are used when there is no messenger cable. They may be insulated cable similar to feeder cables and supported by the pole. Heavier installations utilize twin bare conductors supported by span wires (or bracket arms) just above the level of the trolley wire, near the center of the right-of-way.

Return cable

Return cable

The purpose of return cable is to return power from rails back to the substation. Jumper cables connect all running rails together at several hundred foot intervals and are connected



Messenger wire

Catenary support poles

Catenary

Feeder cables

Fig. 3-16
Examples of Existing Equipment Components of the Catenary System

to return cables which run underground parallel with the tracks. The final connection of return cable is through cable ducts to the substation.

Constant tensioning

Constant Tensioning

Because trolley wire has a tendency of to stretch and sag due to contraction and expansion during extreme temperature changes, trolley wire is supported by a counter weight system which maintains wire at a constant tension regardless of temperature. This system consists of large counter weights attached to trolley wire which slide up and down thereby allowing expansion and contraction with temperature changes while maintaining constant tension on the wire. A more compact device made up of springs in combination with a compensation device to produce constant tension is used at selected stations.

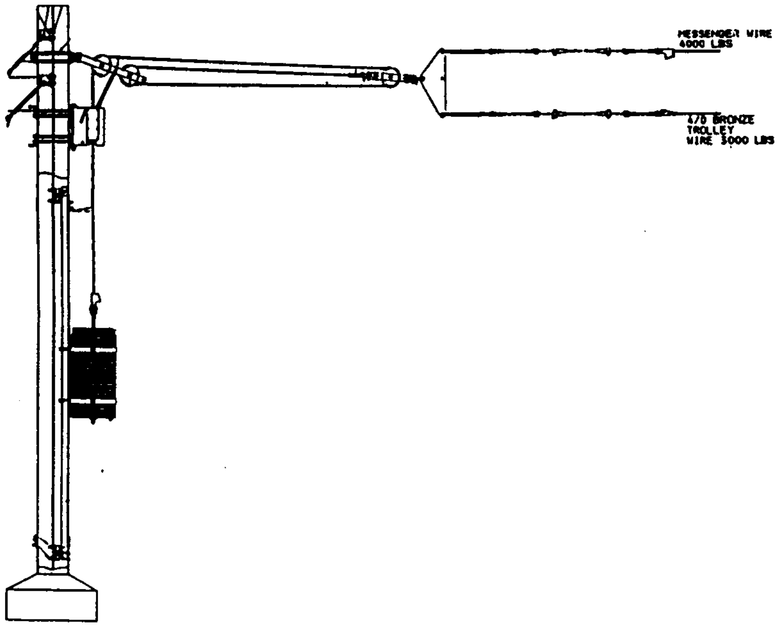


Fig. 3-17
Balance Weight Assembly

3.7.3 Overview

The LRAP power work primarily affects surface stations on the Green Line. Stations within the tunnel do not require power work or modifications at this stage of design.

LRAP will be raising surface platforms to 8" above top of rail and widening station passageways to accommodate wheelchair movement. In performing these modifications, catenary support poles and power manholes will have to be relocated or modified. Additionally, some track sections will be realigned and crossovers moved. All these items will require power design work.

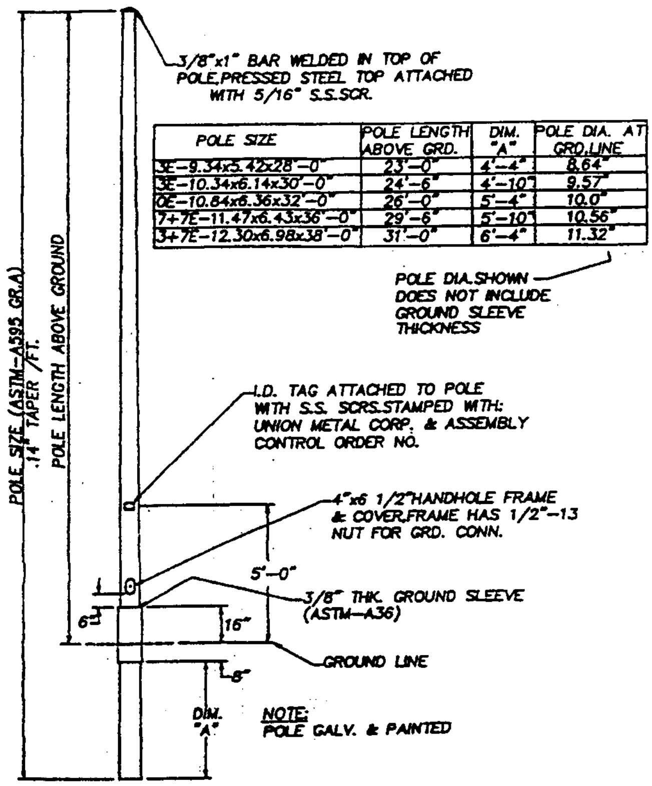
The surface stations that are affected by the power work and the nature of work, along with estimated construction costs are summarized at the end of this report.

For this report, the power work is divided into three major categories, catenary support poles, manholes (mh) and cable ducts, and track work. The following describes typical LRAP work involved with each of these three items.

Catenary Support Poles

Catenary support poles

There are a number of poles scheduled to be relocated consisting of paired poles mounted on each side of the tracks. Single poles mounted in the middle of the tracks have not been scheduled for relocation at this time. Typically pole relocation involves the following considerations:



POLE SIZE	POLE LENGTH ABOVE GRD.	DIM. "A"	POLE DIA. AT GRD.LINE
3E-9.34x5.42x28'-0"	23'-0"	4'-4"	8.64"
3E-10.34x6.14x30'-0"	24'-6"	4'-10"	9.57"
0E-10.84x6.36x32'-0"	26'-0"	5'-4"	10.0"
7+7E-11.47x6.43x36'-0"	29'-6"	5'-10"	10.56"
3+7E-12.30x6.98x38'-0"	31'-0"	6'-4"	11.32"

Fig. 3-18
MBTA Trolley Poles - Standard

1. The new pole locations will be identified by the consultant team. E&M will review the consultants' drawings and perform a site evaluation. From a preliminary review of the plans showing the proposed pole relocations, it is RSD's opinion at this level of design, that there are no major problems installing poles at these sites.

2. The new pole site will be evaluated to determine if it is compatible with the existing catenary system. A list of catenary hardware, including the type of trolley pole, will be compiled. Also it will be determined if additional poles will be required. In stations such as Coolidge Corner where placement of station poles is very confined, a single pole with a double track bracket arm may be mounted on the opposite side (street side) to eliminate the station pole all together.

3. The new pole site will also be evaluated to determine if there are any buried utilities in the area. This will be accomplished by checking MBTA drawings and contacting local utility companies. Note: some poles have a base foundation of over 6'–6". At this stage the pole size, catenary hardware and approximate pole base size will be determined.

4. Because there are only a few poles being installed, it is assumed that the poles and associated pole and catenary hardware will be in MBTA stock. This equipment will be immediately ordered to replace equipment used.

5. The consultant team will provide construction specifications, drawings, installation details and a schedule for the work to be performed. Once this information is reviewed, E&M will advise the consultant team as to what portion of this work will be performed by MBTA forces.

6. The new catenary support poles will be installed before the raising of the platforms. The holes will be hand dug and the exact size of the concrete base will be determined. Ground rods, if required, will also be installed at this time. There are several pole locations that are very close to the edge of the street. The MBTA does not install poles closer than 18" from the edge of the street pavement. Coordinate pole foundation with barrier at back edge of platforms.

7. Once the new poles have been installed, the change over from the old to the new catenary may begin. This change over work will be performed at night, on a weekend or via a diversion. The exact date and time will be dictated by the MBTA. Note: Much time will be saved by having MBTA forces do this work as it can

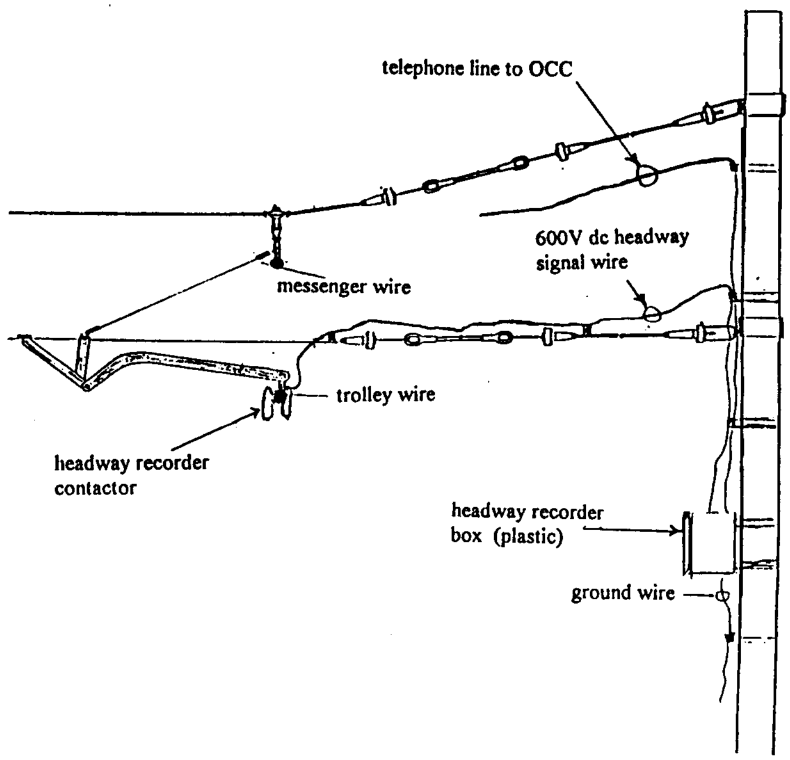


Fig. 3-19
Headway and Recorder - Typical Installation

be performed without shutting off power.

8. Catenary hardware will first be mounted on the new poles and connected to the trolley wire. This will allow the catenary system to remain intact during the cut over. The old catenary equipment will then be removed. Other support equipment such as headway recorders and trolley pan track switches will also be relocated at this time.

9. The final step will be to test the new catenary alignment and observing revenue service as it passes through it. The MBTA plans will be upgraded to reflect the changes.

10. It is estimated that it takes approximately three days to set a pole and six to eight hours to install the catenary equipment to the pole.

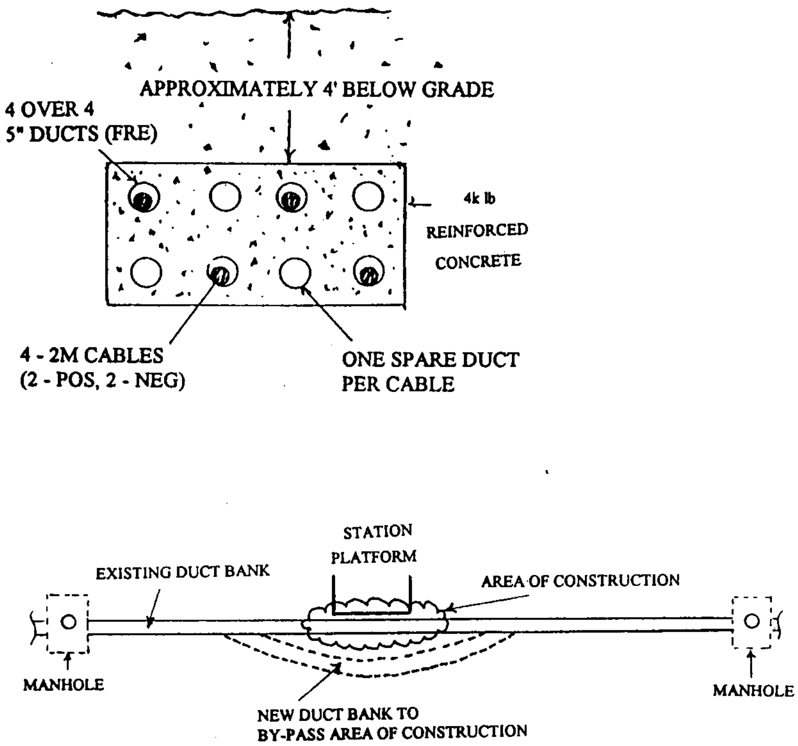


Fig. 3-20
Duct Bank Relocation

Cable Ducts & Manholes

Cable Ducts and Manholes

There are approximately nine manholes and one duct bank relocation scheduled for this project. Typically cable duct and manhole work involves the following considerations:

1. It is assumed that most of the manholes requiring modifications contain low voltage communication or signal cables. At this stage of design it is recommended that only manhole modifications, not manhole relocation, be considered. Relocation of a communication manhole could cost $20,000 to $30,000 and a power manhole $50,000 to $70,000 under normal conditions.

2. Most of the manhole modifications will consist of the installation of an 8" collar to compensate for the additional depth of the concrete platform. The estimated cost to install a 8" collar is $5,000. In some manholes the entrance hole may have to be relocated to a different section of the manhole. This may require adding a section to the side of the manhole to accommodate the new entrance hole.

3. At Washington Square a trolley pole with attached power switch box and cables is scheduled for relocation. Once the new pole and switch box is installed, a new 4 conduit duct will be installed from the existing manhole to the base of the pole. The new cable duct is approximately 50'. The cable will leave the duct and run in metal conduit to the switch box. From the switch box the cable will run up the pole and be connected to the catenary system. During non–peak hours the existing cables will be disconnected and the new ones connected.

Track Work

Track Work

The design calls for new crossovers to be installed. There is specialized catenary work required for the new crossovers as it involves running trolley wire over the entire section of crossover track. Typically crossover work involves the following stages:

1. Return Cables

   There is a return cable network presently in place that has to be maintained during crossover construction. Before removing the return cables in the area where the new crossover is to be installed, temporary return jumper cables will be installed. This will assure that the track return system stays continuous during construction.

2. Typically a negative return system consists as follows:

   - A main return cable runs from the substation through a cable duct line that runs parallel with the tracks. Its purpose is to bring return current from the rails back to the substation.

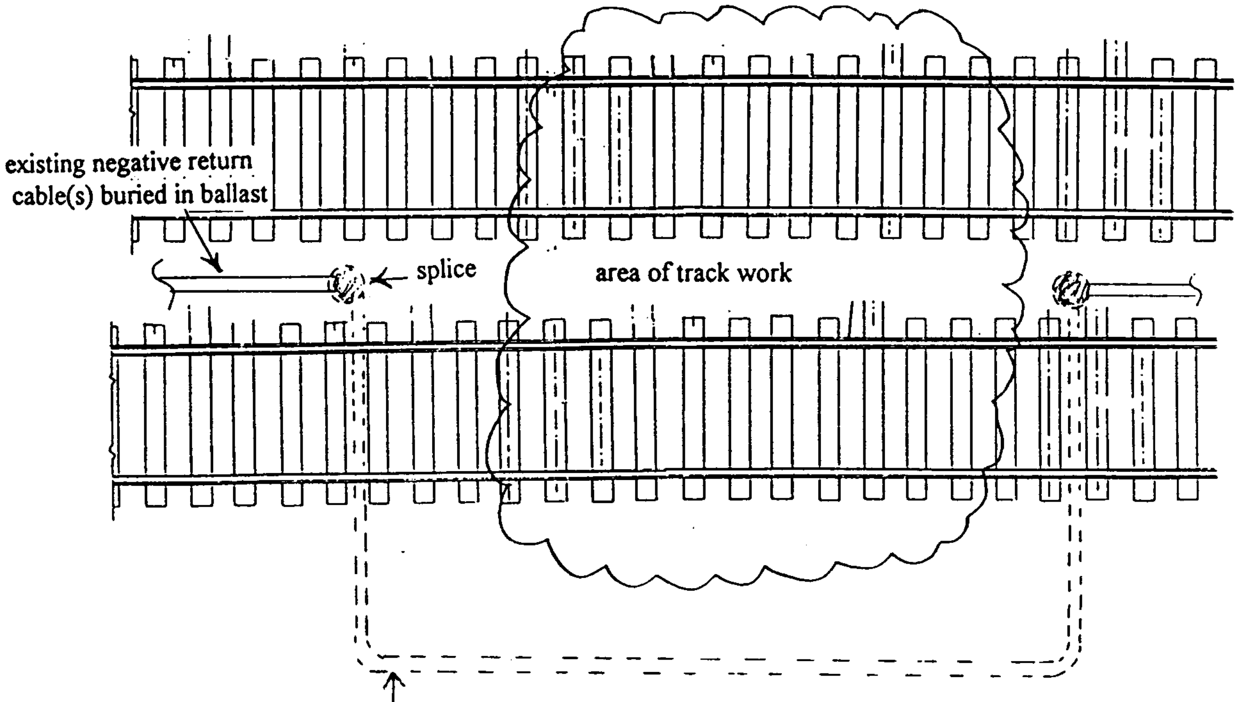


Fig. 3-21
Return Cable Relocation

- There may also be a direct buried return cable(s) that run between the tracks. At every few hundred feet there are jumpers that connect all rails and then connect to the buried return cable.

- At every several hundred feet the main return cable in the duct line and the direct buried return cable are connected, usually in a power manhole.

3. Catenary

New poles associated with new crossover will be installed with the crossover. The crossover catenary, including trolley and messenger wires, will be fully connected, energized and tested.

The original crossover may now be removed, return cable installed and unused poles removed.

4.1 Civil Engineering

This section of the *Project Design Manual* deals with the civil engineering issues related to construction of the Green Line stations and trackwork. These guidelines include roadways, sidewalks, traffic controls, drainage and utilities. The guidelines incorporate frequently used formulas and design information, but applicable codes and regulations should be consulted for specific design situations. The section is concerned with providing engineering elements that are durable and compatible with existing site features. The design should also consider various impacts of each element on the character of the stations.

Durability and Maintainability

Durability and Maintainability

The design of roadways, drainage and utilities all contribute to the durability of the infrastructure systems. The methods of construction and materials recommended in this section have an impact on roadways, drainage and utilities.

Compatibility

Compatibility

The design guidelines of roadways and the infrastructure systems are essential in providing reconstructed sections which are compatible with existing systems. The materials used for new construction should meet technical standards for long life and economics. Where contiguous with existing materials, the new materials should match or compliment the existing materials and be physically compatible. The engineering elements should also meet the standard details and construction practices of the municipality or MHD.

Safety

Safety

The engineering elements will provide safe sidewalks, roadways and utility lines. Standards contained in this Chapter pertain to reconstruction of existing streets and intersections where this is a project component. All designs shall conform to AASHTO, MHD, MBTA, and applicable municipal standards.

4.1.1 Pavement Design and Materials

Roadway Pavement at Track Crossing

Roadway Pavement at Track Crossing

The pavement shall be bituminous concrete as specified by the MHD in Standard Specifications for Highways and Bridges and designed to a thickness in accordance with the MBTA Standards.

Horizontal Alignment

Horizontal Alignment

The minimum radii for horizontal curves on streets and at intersections where track crossings are shall be determined in accordance with AASHTO and MBTA standards. Roadway horizontal curvature shall be circular without the use of easement or spiraled curves. The Designer shall also consider sight distance at the intersections when the transit vehicles stop at the stations. The minimum sight distance shall be 200′. The rate of superelevation outside commercial or built-up areas shall be governed by terrain conditions, traffic demand, and design speed; but in no case shall exceed 0.06.

Vertical Alignment

Vertical Alignment

The minimum length of vertical curves shall be based on profile grades and sight distance, and shall be determined in accordance with AASHTO and MHD standards.

4.1.2 Sidewalk Design Criteria

The sidewalk surface shall be cement concrete, bituminous concrete, precast concrete pavers, or brick as required to match the platform or the existing sidewalk surface materials. The cement concrete shall have a minimum depth of 4″ and 6″ at driveways or platform ends subject to roadway vehicles. The bituminous concrete shall have a minimum depth of 5″. Precast concrete pavers shall be adhered to a one inch bituminous concrete setting bed over a 4″ cement concrete, or 5″ bituminous concrete base. The brick shall be laid in a mortar bed. All surface material shall be laid on a sub-base of compacted gravel. The sidewalk shall be sloped toward the curb, the maximum cross slope shall be 1/4" per foot.

A curb ramp shall be provided at each corner of each intersection. The curb ramps at station sites to be constructed should be installed with surface material similar to the existing sidewalk material. All curb ramps shall have non-slip surface.

Cross Slope	Max. 1/4" per foot (2%)
Profile Grade	Max. 5%
Sidewalk Width	4' minimum clear

4.1.3 Curbing and Barriers

In areas where the back of the platform abuts the roadway two types of treatment may be used. A cement concrete barrier or a granite curb and low concrete wall. See ***Figs. 2-80*** and ***2-137***. The barriers shall be set at the roadway line and elevation and will be installed without curbing. The low concrete wall shall be set back from a granite curb which is set at the roadway line. The treatment shall be approved by the Authority. The location and end treatment of the barrier of wall shall conform to AASHTO and the City of Boston standards. A decorative steel railing should be installed at the top of barriers with the top of barrier a minimum of 3'-6" above the platform. (See Sections 2.4, Platforms and 2.11, Barriers.)

- Vertical granite curbing with a 6" reveal shall be utilized on MBTA property.
- The cement concrete barrier to be used on the MBTA property shall be configuration as shown on the sketches.
- Roads and streets in jurisdictions other than the MBTA shall have curbing in accordance with the appropriate standards and/or codes.
- The concrete and reinforcing shall be protected against salt damage.

4.1.4 Traffic Control Devices

Signals

Traffic signals shall be designed and installed in accordance with the "Manual on Uniform Traffic Control Devices" (MUTCD), supplemented by applicable MHD standards. **Signals**

The signal poles shall be placed out of the path of travel, leaving adequate clearances for sidewalks and curb ramps. The location of pedestrian push buttons shall be planned to allow adequate clearance time for crossing the roadway.

Signs

Signs

Street name, regulatory, warning, guide and other signs shall be designed in accordance with MUTCD and MHD standards, and/or local guidelines. The placement of signs within the road right-of-way must be approved by the owner. The sign posts shall be placed out of the path of travel. The signs should also have vertical headroom clearance.

Station identification signs shall be designed and located in conformance with the MBTA guidelines and standards. A description of the MBTA signage in the station areas is given in Chapter 2.9. Station signs at station entrances shall be placed with adequate height and setback from the street so as not to obscure sight distance for vehicles exiting stations.

Pavement Markings

Pavement Markings

Maintenance and Protection of Traffic

The design consultant shall design plans for maintenance and protection of vehicular and pedestrian traffic during construction of Green Line facilities. The plans shall include schedule and methods of street closure. The plans will also include detours over temporary roadways. Parking and pedestrian access shall be maintained. Emergency access to MBTA and abutting property shall be provided at all times. The maintenance and protection of traffic shall be coordinated with the municipal traffic department.

Pavement marking layout and design shall be in conformance with applicable MUTCD, MBTA, and MHD standards.

All crosswalk and lane striping shall be of thermoplastic material. Stop lines, directional arrows, gore markings, and street lettering shall be reflectorized white paint.

4.1.5 Pedestrian Crosswalks

The location of pedestrian crosswalks near station entrances shall be based on curb ramps, projected pedestrian and traffic volume, speed limits, roadway widths, curves and neighborhood characteristics. The pedestrian crosswalks shall also be placed in accordance with the ADA requirements. Warning signs shall be installed in advance of crosswalk locations, and adequate visibility provided by on-street parking prohibitions close to crosswalks.

The need for installation of pedestrian-actuated traffic signals shall conform in design and location to MUTCD standards for pedestrian signal indications. The location of the pedestrian push button should be planned with clearance cycle of the signal.

4.1.6 Grade Crossings

All track/highway crossings shall conform to AASHTO sight distance requirements with given transit vehicle and highway vehicle design speeds.

Traffic control systems for track/highway grade crossings shall conform to MUTCD standard, and shall be consistent with applicable requirements of the MHD and local jurisdictions.

The grade crossings are a system-wide element. The program specifies full-depth rubber crossing at vehicular and pedestrian crossings when track geometry permits. Precast crossings designed for use without ties may be installed at selected locations with approval of the Authority.

Maintenance and Protection of Vehicle and Pedestrian Traffic

Maintenance and Protection of Vehicle and Pedestrian Traffic

During the design of each station the provisions should be made for the maintenance and protection of roadway, vehicular and pedestrian traffic during construction. Each station design must include a roadway traffic maintenance plan which is closely coordinated with the governing municipality. The use of staged construction procedures shall be thoroughly investigated as alternates to street closing and construction of temporary detours on structures.

Any construction or excavation activity affecting a street closure shall be carefully scheduled and staged in order to keep the street closures to a minimum. The activity shall be phased so that an adequate number of traffic lanes on each street will be available.

Pedestrian Access

Pedestrian Access

Safe pedestrian access shall be provided to abutting land-uses at all times. No commercial, residential or other type facility shall be denied its access during any time that the facility is normally open.

Unobstructed walkways of 6′ minimum width shall be provided and maintained at all times on each side of all streets within the construction areas, either on pavement or on a portion of the decked areas.

The temporary pedestrian walkways shall be separated from the roadway area by an approved barricade.

Locations of high pedestrian activity shall be provided with walkways wide enough to safely accommodate the pedestrian demand. Sizing of temporary walkways shall be determined using a rate of one foot of width for every 12 persons per minute. 6′, however, shall be the minimum width for temporary walkways.

The requirements for protection and maintenance for the railroad service during construction shall be included in the design of each station. Rail service shall be protected during regular hours, and track construction shall be performed during no service hours. The design of any track work on rail crossings shall be coordinated with the MBTA to maintain open rail lines.

4.1.7 Drainage

Existing drainage patterns shall be maintained wherever possible.

Surface and subsurface drainage of the railroad should be handled by a system of gravity - flowing longitudinal ditches that feed into the municipal storm sewer. Ditches should be designed to handle anticipated flows without silting or scouring. The drainage shall be designed to drain away from the railbed, roadway, and pedestrian path of travel. In areas where the railbed is in a high water table or is subject to runoff of large paved areas, track drains should be considered. Track drains can be installed in locations where trenches are not feasible. The track drains collect runoff water from the surface and the flow through the ballast then pipe it to the storm sewer system or ditch. Positive means of removal of rainwater must be supplied at the low points in the ditch profile. Those means may include tying into municipal storm sewer systems by use of catch basins, or culverts.

Roadway surface drainage shall discharge into catch basins flowing to municipal storm sewer systems.

Drainage systems that discharge to an existing wetland or are within 100′ of a wetland must comply with the rules and regulations of the local Conservation Commission and must receive a permit from the Conservation Commission. They require an analysis of 10 year and 100 year storms.

Drainage systems connecting to an existing storm drain may require a permit or approval from the drainage system owner. They should be contacted to determine specific requirements.

Design Storm Computation

Design Storm Computation

1. Rational Equation:

   Design flows shall be computed by the Rational Equation:

   Q = CiA

   where, Q = Runoff quantity, in cfs,
   C = Coefficient of Runoff,
   i = Rainfall intensity, inches/hour, and
   A = Drainage area, in acres.

2. Design Frequency:

   The track drainage system, including all open trackbed areas exposed to direct precipitation, shall be designed to accommodate the peak flows produced by the 50 year rainfall event. All runoff shall be fully contained within the drainage system; no surcharge will be allowed for catch basins and the capacity of all pipes, ditches and etc. shall equal or exceed the 50 year runoff.

The drainage systems for all areas adjacent to the station such as parking lots and station accessways shall be designed to accommodate flows produced by a 10-year storm unless otherwise specified in by regulatory authorities. Due regard shall be given to the capacity of the receiving storm-drain system.

The minimum time of concentration used shall be 5 minutes.

The time of concentration, rainfall intensity and coefficient of runoff shall be calculated using the Highway Design Manual by the Massachusetts Department of Public Works.

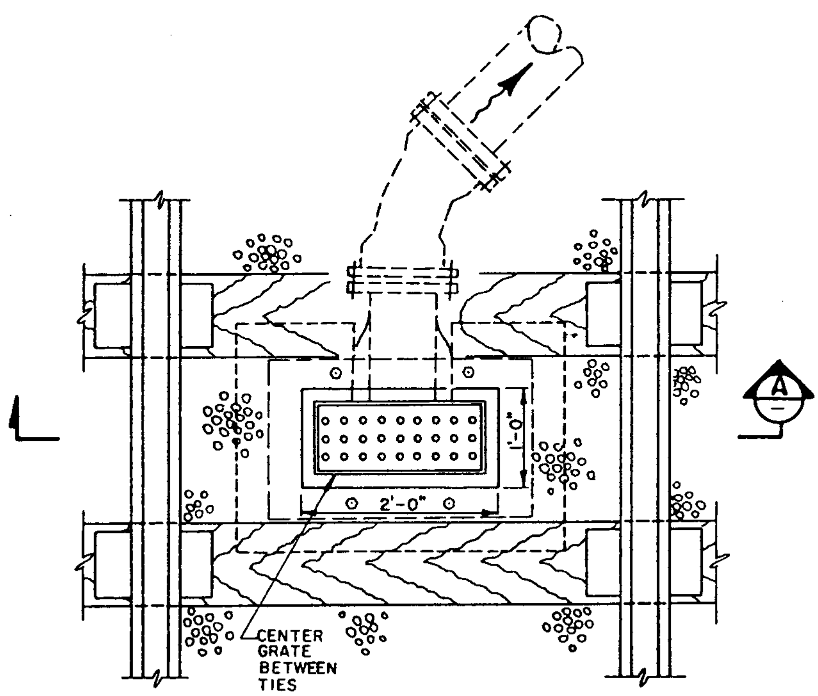


Fig. 4-1
Track Drainage Plan

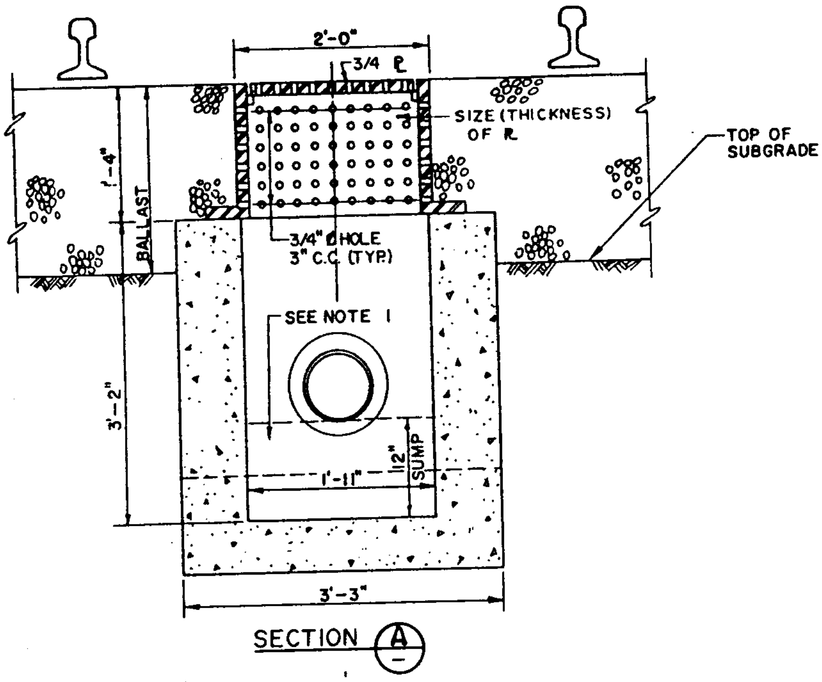


Fig. 4-2
Track Drainage Section A

Drainage Pipes

Drainage Pipes

1. Material, Cover and Structural Requirements:

   Reinforced concrete pipes shall be used. Minimum pipe size shall be 12" Culverts shall have a minimum diameter of 18".

   Pipes immediately adjacent to and under rapid transit tracks shall be PVC pressure pipe, Class 165 (DR25). Equivalent non-metallic pipes shall be considered for this use.

   Pipes under highways, parking lots and driveways shall be designed for HS20 loading. They shall have a minimum cover of 1' from top of pavement to top of pipe.

2. Flow:

Manning's Equation, as shown below, shall be used.

$$Q = \frac{0.463D^{8/3}}{n} * S^{1/2}$$

where, full capacity,

S = Pipe slope (feet/foot),
Q = Flow (cubic feet per second),
n = Manning's roughness coefficient ($feet^{1/6}$), and
D = Pipe diameter (feet).

Pipes shall be designed for uniform flow, with a preferred velocity in the range of 3′ to 9′ per second. Maximum headwater for culverts shall be 1-1/2 times the pipe diameter. At design flows, water shall not back up at the pipe entrance to an elevation higher than six inches below top of railroad subgrade or roadway pavement.

No pipe shall be designed with a size smaller than the next pipe upstream.

3. Manholes:

Manholes shall be installed at all pipe junctions and grade or alignment change points. Maximum pipe length between manholes shall be 300′.

4. Catch Basins:

Catch basins shall be installed at all ground or pavement surface low points and all grades not drained by other means. The maximum interval between catch basins shall be 300′.

Catch basins shall have a 30″ deep sump and a cast iron hood, frame and grate. Bicycle safe grates shall be used in all reconstructed areas. The location of grates shall be placed away from the curb ramp and out of the path of travel.

Perforated Pipe Drains

Perforated Pipe Drains

Where ditches are not permitted by space, where additional flow capacity is needed, or where required to reduce underground hydrostatic pressure, perforated pipe drains shall be used. The pipes shall be perforated PVC porous, type free from perforations, of a minimum 6" in diameter.

Filters shall be used with all perforated pipe drains to prevent accumulation of sediment in the pipes. Filter material may consist of suitable graded crushed stone, synthetic filter material, or a combination thereof. The filter envelope shall extend a minimum of 8" beyond the outside diameter of the pipe.

Perforated pipe drains shall discharge to a gravity drainage system. Care shall be taken to ensure that perforated pipe drains are not blocked by high water levels at the outlet. Relatively impervious materials such as loam or topsoil shall not be installed vertically above these pipe drains.

MDC gas traps or oil-water separators shall be provided in areas where runoff is subject to contamination with petroleum products and where required by regulatory authorities.

4.1.8 Privately and Publicly Owned Utilities

The Designer shall contact owners of all public and private utilities serving in the project area for dig safe and shall verify the location of any utilities in the work area. The Designer shall check the survey drawings using the best available information to maximize the accuracy of utility locations, and shall also determine what, if any, measures are needed to protect existing utilities.

Requirements for connections to existing utilities and their ability to provide the service needed by the LRAP Project shall be coordinated with the utility owner.

The designer shall develop a list of utilities needed and contact persons for this project. A record of all memoranda and correspondences with utility companies shall be kept in the project file and copied to the Authority.

Utility Maintenance during Construction

Utility Maintenance during Construction

Temporary replacements, support structures for relocations of utility systems for construction purposes shall be in conformance with the current standards and practices of the owning and/or operating utility agency or company and shall be compatible with present and future utility requirements.

Utility service to areas adjacent to the LRAP must be maintained at all times during construction unless specifically authorized by the MBTA with the concurrence of the affected utility owner. Temporary interruptions of service shall be kept to a minimum and shall be allowed only when no other reasonable alterative exists.

Provisions shall be made for temporary interim surface drainage systems to minimize stormwater inflow to excavation areas during construction.

All utilities within or adjacent to the LRAP construction activities shall be evaluated to determine their potential for settlement or other damage as a result of activities. Relocation, replacement and/or support systems shall be considered for those utilities that may be affected as a result of the LRAP project activities.

Utility Relocation (Temporary and Permanent)

Utility Relocation (Temporary and Permanent)

In order to maintain and protect utility services during construction, it may be necessary to either temporarily or permanently relocate the utility service either prior to or during construction. The designer, in close coordination with the utility company or agency, shall determine which utilities shall be temporarily relocated and which shall be permanently relocated.

All permanent relocations shall be designed in accordance with all applicable codes, design standards, and requirements of the utility owner. The utility owner shall review and approve all temporary and permanent relocations. Existing equipment shall be relocated, rather than replaced, whenever possible with approval of the owner.

Utility Design Standards

Utility Design Standards

1. Water Lines for Domestic and Fire Service

All water pipes shall be designed in accordance with AWWA standards and standards of the local water utility. All valves, fire hydrants, and other appurtenances shall conform to local standards and AWWA requirements. Pipe and appurtenances used for fire protection shall also conform to NFPA requirements.

When separate fire and domestic service pipes are required, detector checks shall be used near the connection of the fire service pipe to the water main.

Hydrant locations shall be approved by the local fire department.

Minimum pipe sizes shall be 8" if two or more hydrants are connected to it and 6" for a single hydrant. Flow test data shall be used to size water pipes whenever possible. Pipes for domestic service shall be sized in accordance with AWWA, Plumbing Code, and the water utility criteria. All ductile iron pipe shall be cement lined with suitable exterior corrosion protection.

All pipe connected to a potable water system shall be pressure tested and disinfected before it is placed in service. Water meters shall be in accordance with local requirements and AWWA standards. Water pipes shall have a minimum cover of 5'.

2. Sanitary Sewers

Sanitary sewers shall be designed in accordance with state and local health codes and utility requirements. Minimum velocities for sanitary sewers shall be 2 ft/sec unless local codes require a higher velocity. The maximum velocity shall be 10 ft/sec.

Sewers from stations shall be connected to local sewers whenever possible. Permits for the connection must be obtained from the proper authorities.

Flows in existing sewers shall be measured whenever possible. Flow in new pipes and pipes where flows cannot be measured shall be estimated using Massachusetts DEQE standards. Peak flows shall be estimated using ASCE Manual 37 - Design and Construction of Sanitary and Storm Sewer or other approved method. Sanitary flows from large commercial or industrial facilities shall be investigated and considered during design.

Manholes shall be located at all changes of direction, junctions, and/or grade changes and a maximum interval of 300′. Manholes shall have a minimum inside diameter of 4 feet and shall have a cast iron frame and cover in accordance with MHD Standards. Drop manholes shall be used when grade changes exceed 2′.

The minimum size of gravity sewers shall be 6″ unless the utility owner specifies another size.

Sewers shall be 10′ horizontally from water pipes whenever possible. Sewers shall pass a minimum of 3′ below water pipes whenever possible. If these requirements cannot be met, a concrete encasement or other protective measure required by local authorities or utilities shall be provided for 10′ prior to or beyond the water pipe.

Sewers shall be buried 3′ whenever possible, but in no event less than 1′.

3. Other Utilities

Public and private utility owners will be responsible for the relocation design and construction of their own facilities in coordination with the design engineer. The project system design and tie-in connection to the private utilities shall be in accordance with the respective utility owner standards and subject to the review of the MBTA.

The private utility owners shall submit documented estimates for their proposed work relative to this project for MBTA review and approval; this approval must occur prior to any such work commencing.

These services include but are not limited to:

- Gas
- Electric
- Telephone
- CATV (Cable Television)
- Police Alarm
- Fire Alarm
- Fibre-Optics

4. Control Datum

Elevations on all utility design documents shall be based on the USC&GS 1929 mean sea level datum plane; the relationship between this datum and other pertinent datum planes will be noted.

4.2 Structural Engineering

The objective of this section is to provide guidelines for the design of adequate support structures in order to implement safe accessible paths of travel for all pedestrians and Light Rail vehicles used in the Green Line system.

4.2.1 Loads

Dead Loads

Dead loads will be developed from the actual weights of materials used. **Dead Loads**

Live Load

Live loads shall be determined by the Massachusetts State Building Code or AASHTO Specifications, except as modified below: **Live Load**

Sidewalk live load - 250 psf
Street live load - HS 20 Lane loading or 250 psf (min.)
Station extension floor and Stair live load - 100 psf
Electrical equipment rooms & maintenance areas - 250 psf*

* All equipment areas will require verifying the actual loading vs. 250 psf and use the most stringent.

Snow

Structures subject to snow loads shall be designed in accordance with the latest requirements of the Massachusetts State Building Code. **Snow**

Wind

Structures subject to wind loads shall be designed in accordance with the latest requirements of the Massachusetts State Building Code. **Wind**

Earthquake

Earthquake

Above ground structures will be designed to Massachusetts State Building Code or, if applicable, AASHTO Specifications. Earthquake effects on underground structures and portions there of will be considered.

Temperature

Temperature

The design of above ground structures will consider the effects of temperature variation ranging from -20°F to 120°F. The effects of temperature on underground structures will be investigated by the Designer.

Surcharge - Geotechnical

Surcharge - Geotechnical

Earth and water pressures on underground structures shall vary with geographical location.

Determination of soil/structure interaction is the responsibility of the Designer.

The Designer will determine, at a minimum, the following:

- Allowable soil bearing pressure
- Pile loads
- Lateral soil & hydrostatic pressures (not less than 35 psf/ft of depth)
- Groundwater level
- Settlement and heave
- Dewatering & recharge of groundwater
- Backfill specifications
- Building surcharges
- Settlement of adjacent structures
- Buoyancy (minimum fs = 1.10)

Impact

Impact

Loads and forces on structures carrying rail and roadway vehicles will be designed in accordance with the latest AREA and AASHTO Impact Loads.

Superimposed Live Load

Superimposed Live Load

A minimum superimposed live load of 100 psf will be used regardless of depth of structure or, if applicable, AASHTO HS20 loading, whichever is more critical.

Temporary (Construction) Loads

Temporary (Construction) Loads

Construction loads (ie. equipment surcharge, support of excavation) shall be determined by the Designer in accordance with applicable codes and specifications and presented in graphical and numerical form on the contract documents.

Future Use

Future Use

The possibility of new loads from future use of adjacent property shall not be considered.

4.2.2 Load Combinations

Loading Combinations will be in accordance with the following:

1. For above ground buildings, surface stations or other structures not affected by the loads from rail or roadway traffic - Massachusetts State Building Code.

2. For structures loaded by motor vehicles - AASHTO Specifications.

3. For structures carrying railroad traffic - AREA Specifications.

4. For underground structures, the designer shall develop load combinations and consider, at a minimum, the following cases when combining loads in accordance with the applicable code or specification:

   Case I: Maximum vertical loads (DL + LL + surcharge) + Maximum horizontal loads (Full hydrostatic + passive earth (Ko)+ LL + Surcharge)

   Case II: Maximum vertical + Minimum horizontal (reduced hydrostatic + active earth pressure (Ka))

   Case III: Minimum vertical (DL + overburden) + maximum horizontal.

4.2.3 Structural Steel Design

General

General

This section identifies the general design guidelines applicable to the use of structural steel. The Designer will address durability and serviceability in the final design.

Material

Material

Selection of steel types will be determined by the governing codes and the following:

ASTM A36	-	normal use
ASTM A242		
ASTM A440	-	when higher strength is required or
ASTM A514		when economically justifiable
ASTM A572		
ASTM A588		

Structural Steel Subject to Roadway Loading

Structural Steel Subject to Roadway Loading

Structural steel supporting roadway traffic or MBTA bus traffic shall be designed in accordance with AASHTO Specifications.

Structural Steel Subject to Railroad Loading

Structural Steel Subject to Railroad Loading

Structural steel supporting railroad traffic shall be designed in accordance with AREA Specifications.

Other Structural Steel

Other Structural Steel

All other steel not subject to moving loads shall be designed to Massachusetts State Building Code, AISC Specifications for the Design Fabrication and Erection of Structural Steel for Buildings and the AISC Seismic Provisions for Structural Steel Buildings.

Connections

Connections

The Structural Engineer is responsible for calculating all stresses, reactions and moments occurring at all connections in the structure. For those connections considered normal and usual, the Engineer may specify special reaction data and all other pertinent data required for the fabricator to select and detail those connections in the shop drawings. The Structural Engineer will design and detail any connection considered unusual.

Weldments - Welds subject to vehicular loadings will meet the requirements of the joint bridge code AASHTO/AWS-D1.5. All other weldments will use AWS D1.1.

Bolted Connections - For general use, ASTM A325 bolts in accordance with AISC Manual of Steel Construction Volume II Connections.

Corrosion Protection

Corrosion Protection

The Designer shall consider corrosion protection for all structural steel exposed to weather. All steel not galvanized shall be shop prime painted. All steel exposed to view shall be finish coated.

4.2.4 Reinforced Concrete Design

General

General

This section identifies the general design criteria applicable to the use of reinforced concrete. The Designer will address durability and serviceability in the final design.

Material

Material

Material selection and mix design will be determined by the governing codes and specifications and the following:

Cast-In-Place Concrete -	Minimum Design Strength f'c = 4000 psi
Reinforcement Steel -	ASTM A615 - Grade 60

Reinforced Concrete Subject to Roadway Loading

Reinforced Concrete Subject to Roadway Loading

Reinforced concrete supporting roadway traffic or MBTA bus traffic will be designed in accordance with the latest AASHTO Specifications.

Reinforced Concrete Subject to Railroad Loading

Reinforced Concrete Subject to Railroad Loading

Reinforced concrete supporting railroad traffic will be designed in accordance with AREA Specifications.

Other Reinforced Concrete

Other Reinforced Concrete

All other reinforced concrete not subject to moving vehicle loads will be designed in accordance with ACI-318.

Corrosion Protection

Corrosion Protection

For reinforced concrete surfaces subjected to the effects of de-icing salts, freeze-thaw weather conditions and stray current, the Designer shall consider one or more of the following:

- protective reinforcement coating
- higher `Z' factor
- increase in concrete cover
- decrease water/cement ratio (use of water reducing admixtures)
- use of fly ash or silica fume
- use of concrete sealants
- use of DCI

The Designer will evaluate the specific type of exposure and incorporate appropriate protection in the final design.

4.2.5 Precast Concrete

General

General

The manufacture, handling, transport and installation procedures of all precast concrete shall require approval by the Engineer prior to construction. Precast concrete units shall be designed to meet the latest requirements of ACI and PCI. In addition, the manufacturer shall address durability and serviceability for precast concrete in corrosive environments.

Materials

Materials

Precast units shall be fabricated of Portland cement concrete with a minimum 28 day compressive strength of 5000 psi, a maximum 3" slump and maximum aggregate size of 3/4".

Reinforcement shall be welded steel wire fabric and/or deformed bars conforming to ASTM A615, Grade 60.

Specialty Type Units

Specialty Type Units

- Precast units that require tactile warning strips shall be cast integrally with the unit.
- Traffic barriers shall conform to the latest approved MHD requirements of a configuration 'f' shape, or other approved cast-in-place barrier. See Section 2.11, Barriers.
- For criteria on precast pavers; see Paving Section 2.4.5.

4.2.6 Timber and Stress Grade Lumber

General

General

This section identifies the general design criteria applicable to the use of timber supports, (not including timber pile foundations), lumber and its fastenings. For permanent timber structures, the designer must consider durability, low maintenance, protection from moisture and insects.

The type of treatment selected shall reflect the use group of the structure, exposure and architectural considerations.

Material

Material

Timber and stress grade lumber shall be 2" (nominal) or more in width and thickness and the stress graded by a recognized inspection bureau.

Unless otherwise specified, all timber hardware shall be galvanized.

Timber Subject to Roadway Loading

Timber Subject to Roadway Loading

Timber supporting roadway traffic or MBTA bus traffic shall be designed in accordance with AASHTO Specifications.

Timber Subject to Railroad Loading

Timber Subject to Railroad Loading

Timber supporting railroad traffic shall be designed in accordance with AREA Specifications.

Timber for Other Structures

Timber for Other Structures

All other timber not subject to moving vehicle loads shall be designed in accordance with the Massachusetts State Building Code and the latest requirements of the National Design Specifications for Stress Grade Lumber and its fastenings.

4.2.7 Waterproofing

General

General

Waterproofing is required for all underground structures, stations, passageways, hoistways or basements subject to groundwater or utility water lines.

Special attention must be given to the modification of existing structures where the original waterproofing shall be breached and spliced to a new system.

Material

Material

Waterproofing shall consist of one or more of the following:

1. Asphalt Membrane Waterproofing System consisting of primer, asphalt and fabric saturated with bituminous substance,

2. Preformed Membrane Waterproofing System consisting of primer, cold applied mastic and either a rubberized asphalt or a modified bituminous reinforced membrane,

3. liquid-applied membrane may be used under special conditions when governing codes allow and only if prior approval is given by the Engineer.

Waterproofing of Structures Subject to Roadway Loading

Waterproofing of Structures Subject to Roadway Loading

Install waterproofing systems in accordance with AASHTO Specifications.

Waterproofing of Other Structures

Install waterproofing systems in accordance with the latest ASTM Standards.

Waterproofing of Other Structures

4.2.8 Support and Protection of Existing Structures

The protection of existing structures from ground movements and subsequent settlement resulting from the excavation work required by the contract shall be investigated. All possible measures to reduce the risk of damage to adjacent buildings and utilities shall be explored.

Geotechnical Services

Geotechnical Services

The Designer is responsible for hiring a Geotechnical Consultant with an in-depth background on soil and groundwater effects on the type of structures adjacent to the work. The Geotechnical Consultant shall be involved in all phases of work from the preliminary investigation to final construction services. The Designer, in conjunction with the geotechnical consultant, shall review all available soil and hydrology information and determine if additional testing is required. If additional testing is necessary in order to give an accurate presentation of the underground strata, the geotechnical consultant shall locate and provide borings log, tabulate and analyze test data.

The Designer shall develop zones of influence and classify existing structures based on the magnitude and extent of settlement for each type of construction method being considered.

Interaction of Construction Methods and Protection of Existing Structures

The Designer and the Geotechnical Consultant shall consider and implement, at a minimum, the following issues that shall affect final design. It should be expected that a continuing re-assessment of the design shall be necessary in order to reach an acceptable level of risk. This is particularly important where drawings and calculations do not exist for some of the older adjacent structures.

- Probability of damage - risk assessment
- Existing conditions
  - structural (including foundation)
  - soil deformations
  - location of structure
- Cost of Potential Damage Repair
  - structural
  - cosmetic (architectural)
- Ability to Control Groundwater
- Cost - Benefit Estimate(s)
- Evaluate Previous Similar Construction
- Degree of confidence in the knowledge of all potential issues

Type of Protection

Type of Protection

The Designer shall consider the following methods to protect these impacted structures:

- underpinning pit piers
- jacked piles
- micro-piles
- concrete cut-off wall or bored pile walls
- soil stabilization - grouting
- braced of tie-back lateral support of excavation

Preconstruction Survey

Preconstruction Survey

After all legal documents, permits and right-of-way acquisition proceedings are in process, the Designer shall conduct a full site survey of all structures in the influence zone. This survey shall take place with the property owners and an independent third party consultant. The Designer shall develop a complete report including photographs and provide all parties an opportunity to add/delete/modify the information before publishing. The Designer shall also allow for two construction monitoring inspections and a final inspection survey with all original parties in attendance. The Designer shall follow with a final report.

Construction Monitoring

Construction Monitoring

The Designer shall develop a construction monitoring program that is incorporated into the project specifications. The objective of the program shall be to gather and analyze data on an on-going basis, process and distribute it quickly and have a set of approved designed parameters in place so action may be immediate in cases where there is potential for damage. The program shall also allow for re-evaluation of construction methods during monitoring.

The data collected and analyzed shall include:

- Settlement of ground surface and at varying levels
- Settlement of Structures
- Horizontal movement of ground
- Horizontal movement of structures
- Groundwater level
- Stress/strain in structure
- Vibration

4.3.1 HVAC

This section of the Project Design Manual describes heating, ventilating and air conditioning requirements for light rail subway stations.

The objectives to be achieved by the HVAC systems is to provide a suitable environment for passengers, authority personnel, and related operational equipment including; signal, communication and electrical equipment.

Codes and Standards

Codes and Standards

Design and construction of HVAC systems for the light rail subway stations shall be in conjunction with and based upon the following codes and standards:

- MBTA Guidelines and Standards and MBTA Transit Facilities Code
- NFPA 130
- Federal, State and Local Codes
- American Disabilities Act and Massachusetts Architectural Access Board

Systems - General

Systems - General

1. The HVAC systems listed below represent a broad scope overview of systems that may be required as part of the light rail accessibility project. Specific requirements for new or upgraded HVAC systems shall be determined by the station designer in conjunction with the MBTA.

2. HVAC systems are as follows:

   - Station/platform ventilation
   - Emergency egress stair pressurization
   - Electric room heating and ventilation
   - Signal room heating, ventilation and air conditioning
   - Communications room heating, ventilation and AC
   - Toilet and janitors closet heating and ventilation
   - Battery room
   - Concession area heating and ventilation

Station/Platform Ventilation System

Station/Platform Ventilation System

The station/platform ventilation system shall be designed to remove smoke, heat and odor from the station to the outdoors by means of the mechanical ventilation system. The system shall be capable of providing 6 air changes per hour.

The station ventilation system shall also be designed to maintain egress routes from the station reasonably clear of smoke, heat and odor and to provide a sufficient quantity of fresh air which would indicate to individuals the direction of egress in the event of an emergency.

All station mechanical ventilation controls shall be coordinated with and interlocked to emergency tunnel ventilation fan management panels.

Exhaust fans for the station ventilation shall be single speed, direct driven and capable of handling 300°F temperature gases for a minimum of one (1) hour. Supply fans shall also be reversible.

Emergency Egress Stair Pressurization System

Emergency Egress Stair Pressurization System

The emergency egress stair pressurization system shall be designed to insure that any emergency egress stair be made smoke-free by providing a mechanical system to supply outdoor air of sufficient quantity so as to prevent the intrusion of smoke into the emergency egress stairway. Pressurization fan shall draw unfiltered, unheated air from the outdoors and discharge into egress stair at a minimum rate of 2500 CFM. A barometric type pressure relief damper located near the top of the stairway shall maintain 0.15" of static pressure in the stairway.

The controls for the emergency egress stairway pressurization system shall be located in the station. The controls shall operate so as to activate the system manually or automatically via the fire alarm system.

Electric Room Heating and Ventilation

Electric Room Heating and Ventilation

The electric room ventilation system shall be designed to maintain a positive pressure in the electric room to eliminate the intrusion of rail dust into the room. The ventilation system shall be designed to remove heat generated by the electrical equipment but not less than 10 air changes per hour.

The fan shall be activated by a reverse acting thermostat set to start fan shall be activated by a reverse acting thermostat set to start fan on a rise in temperature (85°F adjustable).

Filtered make-up air to the electric room shall be provided from the outdoors when possible. Make up air shall pass through 35% efficiency filters at a maximum velocity of 200 ft./min. A magnetic pressure differential gauge shall be provided to indicate the need for filter change. A combination of motorized and barometric relief damper shall be provided in the wall of the electric room to discharge ventilation air. The motorized damper shall be interlocked with the pressurization fan to close when the fan is off. The barometric damper shall be set to maintain a positive pressure in the electric room 0.25" WG.

Heating shall be provided to maintain a minimum space temperature of 50°F. Heating shall be by electric fan powered unit heaters.

Signal Room Heating and Air Conditioning

Signal Room Heating and Air Conditioning

The signal room heating and air conditioning shall be designed to maintain the signal rooms at 78°F and 50% relative humidity maximum in summer and 70°F minimum in winter. Filtered ventilation air shall also be provided from the outdoors to provide a positive pressure in the signal rooms.

Air conditioning as well as dehumidification to the signal room shall be provided by a split system direct expansion fan coil unit within the space and a remote air cooled condensing unit with interconnecting refrigerant piping. An electric resistance heating coil in the fan coil unit shall provide heating in winter.

Toilet and Janitor's Closet Heating and Ventilation

Toilet and Janitor's Closet Heating and Ventilation

The toilet and janitor's closet heating and ventilation shall be designed to maintain 70°F minimum in toilets. Toilet rooms shall be ventilated at a rate of 75 cubic feet per minute (CFM) minimum per each toilet or urinal. Storage rooms and janitor's closet shall be ventilated at a rate of six (6) air changes per hour (minimum).

Heating shall be provided by electrical resistance fan powered wall heaters located in the space with internal thermostats. Ventilation shall be by centrifugal exhaust fans discharging to the outdoors. Exhaust fans shall be interlocked with the light switch. Filtered make-up air shall be drawn from the outdoors wherever possible.

Battery Room Heating and Ventilation

Battery Room Heating and Ventilation

The battery room heating and ventilation shall be maintained at 50°F minimum in the winter. Ventilation shall be provided at a rate to limit the hydrogen concentration to no more than 3% at maximum charge rate. Heating shall be provided by electric resistance fran powered unit heater with integral thermostat to maintain set point.

Ventilation shall be provided by a centrifugal exhaust fan connected to an exhaust hood above the battery rack and discharge to the outdoors. The exhaust hood, fan, and ductwork for the battery exhaust system shall be constructed of stainless steel. The fan motor shall be explosion proof type. Filtered make-up air shall be drawn from the outdoors wherever possible.

Concession Area Heating and Ventilation

Concession Area Heating and Ventilation

The concession area heating and ventilation shall be provided to maintain space temperature of 70°F minimum in the winter. Ventilation shall be provided at the rate of 12 air changes per hour. Ventilation shall be provided by a centrifugal fan discharging to the outdoors. Additional space shall be provided for a specialized exhaust system as may be required by the concession area tenant. The exhaust fan shall be controlled by a local fan ON/OFF switch. Heating for the concession area shall be by an electric resistance fan powered heater with integral thermostat to maintain its set point.

Communications Room Heating, Ventilation and Air Conditioning

Communications Room Heating, Ventilation and Air Conditioning

The communications room heating and air conditioning shall be provided by a self-contained computer room type air conditioning unit. In addition, a ventilation system to maintain a positive pressure in the communications room shall be provided, this system shall be as described for electric rooms.

4.3.2 Plumbing

The plumbing section of the Project Design Manual describes in detail, the technical requirements and conception for the plumbing system design for the MBTA -Light Rail Accessibility Program (LRAP) for surface and subway stations. The purpose of this Manual is to provide design criteria and guidelines for the preparation of drawings and specifications for current and future projects. Due to the diversity of conditions found throughout the system, standardization of all components is impractical.

This Manual recommends standardization only when economic or legal reasons require. The designer should aim to achieve economy of design, based on experience as well as keeping with the consistency of the overall design of the stations.

The plumbing system is designed to provide for safe operation of equipment, ease of maintenance, expendability, long life and to provide accessibility throughout the transit system. All equipment and fixtures are to be designed to the latest codes and standards available at the time of the design and are to incorporate field-proven technology.

While the immediate objective of LRAP is to provide a fully accessible ADA and AAB compliant Light Rail System, the design of the facilities must conform to the requirements and guidelines outlined in this section. Deviations from the design criteria that are demonstrated to be in the interest of a better design must be brought to the attention of the Authority.

Calculations and documentation should be provide in sufficient detail to allow evaluation of the proposed exception of modification. Description of alternatives, advantages, calculations, economic analysis, if required, and cost information must be included. The final decision on any changes will be made by the Authority.

To modify existing or provide new plumbing systems to comply with:

- MBTA Guidelines and Standards and MBTA Transit Facilities Code
- Federal, State and local codes
- NFPA 130
- Massachusetts Architectural Barrier Board
- American Disabilities Act and Massachusetts Architectural Access Board

Phasing and Schedule

Phasing and Schedule

The design of the plumbing systems shall take into effect that the existing stations will remain operative with minimal shut down of services. Consideration shall be given to the design to allow existing systems to remain functioning until ready to be changed-over at an approved time. Coordinate phases of design with the Architect and MBTA.

Domestic Cold Water Service

Domestic Cold Water Service

The domestic cold water service to each station shall be recalculated to determine if the existing system is adequate to handle any increase required by the system changes. If required by the local fire department the domestic cold water system should be sized to include its use as a supply source for a Platform Hose System.

Toilet Rooms

Toilet Rooms

In each toilet room at least one water closet and one lavatory shall be accessible to persons in wheelchairs, or an accessible private lavatory, usable by either sex, shall be provided. Existing restrooms shall be reviewed and rebuilt, if necessary, to comply with ADA and AAB requirements. All new restrooms shall be designed and built in accordance with ADA and AAB requirements.

Cavity Wall Drainage System

Cavity Wall Drainage System

The cavity wall drainage system in each station shall be cleaned and flushed. Any parts of the drainage system affected by the raising of platforms, the installation of stairs or ramps, etc. shall be extended or modified as required to keep the system functional. Any damaged or missing wall access plates shall be replaced to match new or existing finishes.

Wall Hydrant System

Wall Hydrant System

Each station should be provided with a wall hydrant system to facilitate in the cleaning of the station. Each platform shall be provided with its own wall hydrant system to prevent hoses from being laid across the tracks. Existing systems shall be modified and new systems installed where necessary.

Concession Stands

Concession Stands

All water supply and drainage systems connected to any existing concession stands that will be raised along with the platforms, shall be modified to comply with the new conditions of any changes. Any concession stands that will be relocated due to any station changes shall have new water supplies and drainage provided at the new location.

Sump Pumps

Sump Pumps

Modify existing sump pump piping for escalators and elevator services affected by platform raisings and any other changes under the scope of this contract. Clean and flush sump pump piping from the sump pump pit to the main station drainage system. Provide new sump pumps for any new escalator or elevator services installed under the scope of this contract.

4.3.3 Fire Protection

The fire protection section of the Project Design Manual describes in detail, the technical requirements and conception for the fire protection system design for the MBTA - Light Rail Accessibility Program (LRAP) for surface and subway stations. The purpose of this Manual is to provide design criteria and guidelines for the preparation of drawings and specifications for current and future projects. Due to the diversity of conditions found throughout the system, standardization of all components is impractical.

This Manual recommends standardization only when economic or legal reasons require. The designer should aim to achieve economy of design, based on experience as well as keeping with the consistency of the overall design of the stations.

The fire protection system is designed to provide for safe operation of equipment, ease of maintenance, expendability, long life and to provide accessibility throughout the transit system. All equipment and fixtures are to be designed to the latest codes and standards available at the time of the design and are to incorporate field-proven technology.

While the immediate objective of LRAP is to provide a fully accessible ADA and AAB compliant Light Rail System, the design of the facilities must conform to the requirements and guidelines outlined in this section, however, the criteria presented in this section describes minimum requirements only. Deviations from the design criteria that are demonstrated to be in the interest of a better design must be brought to the attention of the Lead Design Engineer. Any exceptions or modifications must be proposed prior to the 30% stage.

Calculations and documentation should be provide in sufficient detail to allow evaluation of the proposed exception of modification. Description of alternatives, advantages, calculations, economic analysis, if required, and cost information must be included. The final decision on any changes will be made by the MBTA.

Phasing and Schedule

Phasing and Schedule

While the immediate objective of LRAP is to provide a fully accessible ADA and AAB compliant Light Rail System, the design of the fire protection systems shall take into effect that the existing stations will remain operative with minimal shut down of services. Consideration shall be given to the design to allow existing systems to remain functioning until ready to be changed-over at an approve time. Coordinate phases of design with the architect and MBTA.

General Guidelines

General Guidelines

Rapid transit stations and tunnels shall be equipped with fire fighting facilities and equipment to limit the spread of fire and to assist in the fighting of a fire in any of these structures. All stations, including subway, depressed, surface and aerial structures shall be equipped with various fire fighting facilities.

Calculations

Calculations

Provide all calculations for the resizing of all existing and any new fire protection services for each station.

Station Standpipe System

Station Standpipe System

A dry standpipe system shall be installed at each station platform. The station standpipe system shall not be connected to the tunnel standpipe system; separate street connections shall be provided for each independent system.

Two (2) 2-1/2" accessible standard pipe valves shall be spaced at 100' intervals.

A street-level connection shall be provided to fill the standpipe system and shall be as required by the local fire department.

All connection points, both fill and draw-off, shall be equipped with threads that conform to the standards of the local fire department. Location of existing standpipes shall be checked to insure they comply with the minimum requirements of ADA and AAB.

Sprinkler System

Sprinkler System

A sprinkler line, heat traced if necessary, with sprinkler heads located as directed by the local fire department shall be installed in all enclosed concession areas. This is required by the MBTA's Guidelines and Specifications. The domestic water system may be used as the supply source if no more than 20 sprinkler heads are installed. (See Section 1205.0 of the Basic Code.)

A water flow alarm valve with the alarm connected to the fire alarm supervisory panel and to Central Control shall be installed in the sprinkler line.

Chemical Systems

Chemical Systems

Systems using carbon dioxide, dry chemical or high expansion foam as selected for special requirements, shall be provided for the Central Instrument Rooms (CIR), Emergency Control Rooms (ECR) and communication rooms. Any existing systems are to be checked to insure that they comply with current codes and regulations.

Fire Extinguishers

Fire Extinguishers

Portable fire extinguishers shall be provided as directed by the local fire department in all electric rooms, Central Instrument Rooms, communications rooms, starter's rooms and main collector's booths.

Standpipe System

Standpipe System

A dry standpipe system shall be installed in all tunnels and shall meet the provisions listed earlier in Section C.

4.4 Electrical

The electrical section of the Project Design Manual describes in detail the technical requirements and conception system for the Electrical Design for the MBTA - Light Rail Accessibility Program for surface and subway stations. The document's requirements for each of the major electrical systems describe design criteria and provide guidelines for preparation of drawings and specifications.

The electrical systems are to be designed to provide for safe operation of equipment, ease of maintenance, expandability, and long life. All equipment and structures are to be designed to the latest codes and standards available at the time of the design and are to incorporate field-proven technology.

General Requirements

General Requirements

The design of the facilities must conform to the requirements and guidelines outlined in this section. However, the criteria presented in this section describe minimum requirements and do not preclude independent thinking by the engineer. Deviations from the design criteria that are demonstrated to be in the interest of a better design must be brought to the attention of the Lead Design Engineer. Any exceptions or modifications must be proposed prior to 30% stage.

Calculations and documentation should be provided in sufficient detail to allow evaluation of the proposed exception or modification. Descriptions of alternatives, advantages, calculations, economic analysis, if required, and cost information must be included. The final decision on any changes will be made by the MBTA.

Codes

Codes

Station designs shall comply with the following standards:

- MBTA Guidelines and Standards and Transit Facilities Code
- Federal State and Local Codes
- NFPA 130
- American Disabilities Act and Massachusetts Architectural Access Board.

Phasing and Schedule

Phasing and Schedule

The design of the electrical system's shall take into effect that the existing stations will remain operative with minimal shut down of services. Consideration shall be given to the design to allow existing system's remain functioning until ready to be cut-over to an approve time. Coordinate in phases of design with the Architect and MBTA.

4.4.1 Required Calculations

The following calculations will be required for each construction package, as applicable (Additional calculations are also required when they would normally be done for a particular construction package's special system; i.e., db coverage for a paging system).:

- Load study - include peak and average demand loads
- Electrical service sizing
- Coordination study
- Lighting
- Engine-generator sizing
- Public address system

4.4.2 Electrical Service

A separate electric service for each of the station's will be required. The Designer shall coordinate with Boston Edison Co. (BECO) for new services or upgrades. Each station shall be independently metered to meet BECO Standards. In addition a Kilo-watt/Hour/Peak Demand meter shall be installed at each service entrance location for use by MBTA personnel. The designer shall select an amperage and voltage that shall best be suited for the station's loads.

4.4.3 Service Equipment

Surface stations shall be provided with large, hinged door, stainless steel, ventilated, electrical enclosures to house electrical service, telecommunications, time clocks, panel boards and metering equipment. The enclosure shall have hinged door/windows for allowing access to view the electrical meter without opening the main door.

Subway stations shall be provided with low-voltage switchgear housed in a separate electric room. The switchgear shall be provided with main circuit breaker (Power monitor Type with electric read out of maintenance capabilities), BECO metering compartment, a meter with phase selector switch, volt meter with phase selector switch, phase failure and phase reversal protection, molded case bolt - on type distribution circuit breakers. Bussing shall be copper and sufficient capacity to meet the amperage required. short circuit current rating to match or exceed the available fault. A NEMA 12 enclosure shall be provided for extended protection, all breakers shall be labeled with phenoic plaques.

Panel Boards

Panel Boards

Provide circuit breaker panelboards, dead front-safety type, equipped thermal-magnetic, bolt-on, molded case circuit breakers. The panelboards,shall be in NEMA 12 enclosure for extended protection. The panel boards shall be provided with copper bus. Provide a separate ground bus in each panel. Each panel shall be provided with type written directory.

Step-Down Transformers

Step-Down Transformers

Provide 480 volt, 3 phase delta primary 120/208 volt, 3 phase, 4 wire wye, air cooled transformers where indicated with 2 (2-1/2%) F.C.A.N. taps and 2 (2-1/2%) F.C.B.N. taps. "T" type not accepted.

Transformers must comply with NEMA standards. Provide enclosure with minimum steel weight of 12 gauge and Class "H" insulation of 150 degrees C rise at 40 degrees C ambient.

Emergency Generator System

Emergency Generator System

A diesel emergency generator shall be provided at the subway stations. The generator shall operate automatically during the normal power outage and provide power to all life safety equipment, elevators, and communications equipment. Emergency loads will be started sequentially.

The emergency generator system is provided with automatic transfer switches and distribution panels. All emergency equipment shall be located in two hour rated dedicated rooms.

Automatic Transfer Switches

Automatic Transfer Switches

Automatic transfer switches shall be sized in accordance with manufacturer's recommendations. The transfer switch shall be 4-pole, manual by-pass type.

Battery Inverter Units

Battery Inverter Units

In addition to the generator, a battery inverter system is existing at each subway system. It is provided to automatically maintain station emergency lighting during the interval when normal power fails and the generator starts. Inverter system equipment is located in separate rooms. These systems may require ?? or relocation.

Grounding

Grounding

- Ground all systems and equipment in accordance with National Electrical Code, local requirements, industry practice.
- The ground bus of the main switchboard shall be connected to the main grounding electrode specified below by means of insulated conductors run in conduit.
- The main grounding electrode shall be brought to the nearest accessible point on the metallic main water service pipe. Connection shall be made on the street side of the main valve utilizing a ground clamp of a type specifically manufactured for the purpose. Bonding jumpers shall be provided around the water meters and around insulating joints and/or sections.

- Provide grounding bonds between all metallic conduits of the light and power system which enter and leave cable chambers or other non-metallic cable pulling and splicing boxes. This shall be accomplish this by equipping the conduits with bushings of the grounding type individually cross connected.

Raceways

Raceways

- Rigid metal conduit shall be heavy wall zinc coated steel and shall be used where conduit is exposed or utilized underground.

- Surface metal raceways shall not be utilized in general.

- Flexible metal conduit shall be used for connections to lighting fixtures and motors. Liquid tight flexible metal conduit shall be used for the above connections which are located in moist location. All flexible connections shall include a grounding conductor.

Conductors

Conductors

1. Conductors shall be copper with 600V insulation, XHHW for feeders and for branch circuitry.

   Conductors shall be of soft drawn 98% minimum conductivity properly refined copper, solid construction where No. 10 AWG and smaller; stranded construction where No. 8 AWG and larger.

   Final connections to motors shall be made with 18" of neoprene sheathed flexible conduit.

   Minimum conductor size shall be No. 10 AWG installed in conduit. Motor control circuit wiring shall be, at minimum, No. 14 AWG installed in conduit.

   Fire alarm system wiring shall be as per manufacturers recommendations.

2. The insulation of covering of each wire or cable shall be color coded so as to provide for circuit identification as specified below.

Circuits	Circuits	
Black	Brown	A
Red	Orange	B
Blue	Yellow	C
White	Grey	Neutral
Green	Green	Ground w/ yellow tracer

Fire Alarm

Fire Alarm

Although this system is not a key station item, it is required by the MBTA's Guidelines and Standards and the MBTA's Transit Facilities Code.

Provide an addressable intelligent Fire Alarm System

The Fire Alarm System is provided with an automatic and manual Class A closed circuit, local energy, and double supervised system with battery standby and connected to the emergency generator.

The system is provided with necessary hardware and software interface with existing computers to provide an overall functioning system. Remote indications shall be provided to local fire department, Dewey Control, Arborway, and MBTA Police Headquarters.

The system shall be comprised of control panels, manual pull stations smoke and heat detectors, monitoring of sprinkler systems, audio/visual systems. All wiring shall be in rigid conduit.

Feb. 9, 1995
MBTA Light Rail Accessibility Program
(REVISED) Description of Ramp Zone Analysis

APPENDIX No. 1

0. Introduction

The primary access issue at all Green Line platforms, for both surface and subway stations, involves the loading/unloading of the trains. The MBTA has decided to gradually replace the existing Type 7 Light Rail Vehicles (LRV's), which require the use of three steps to load/unload, with new Low Floor Vehicles (LFV's). This appendix discusses the impact that the introduction of the new fleet of LFV's will have on some aspects of the stations, and particularly the dimensional requirements that the operation of these trains will impose on the platforms. Due to the complexity of this issue, and especially to the multiplicity of possible scenarios, a methodology has been developed in order to assist the station designer in the task of considering these dimensional requirements.

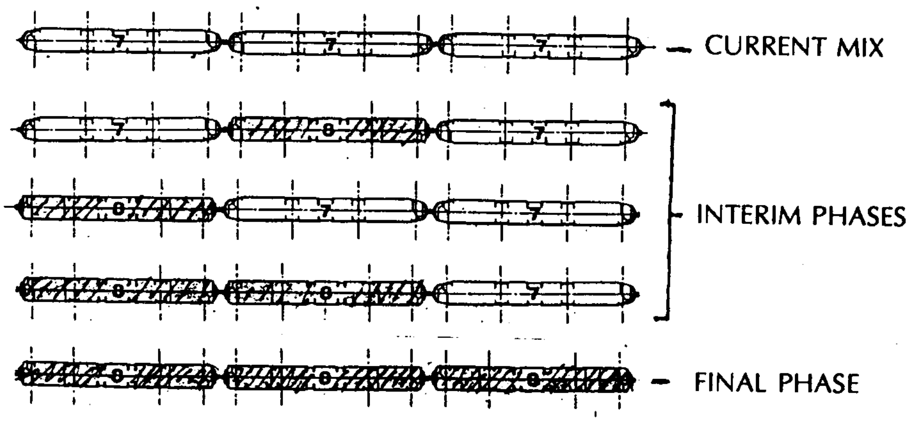
Although this methodology takes into consideration all the elements known at the time this report is produced, it should be used as a general design tool only, since many of the assumptions on which this analysis is based are likely to change over time. As additional requirements are developed, and new constraints are defined, this methodology will have to be adjusted accordingly. Moreover, given the fact that every station will present particular conditions and problems, the application of this methodology should be evaluated by the designer on a case by case basis.

The methodology is described in this appendix, following a systematic introduction of the dimensional and operational issues of relevance to the problem.

1. *Train mix combinations*

The process of gradually substituting the Type 7 LRV cars with new LFV's will take place over a number of years. During this interim period, the MBTA will use a mix of both types of cars, and a total flexibility of combinations should be assured in order to facilitate the train operations.

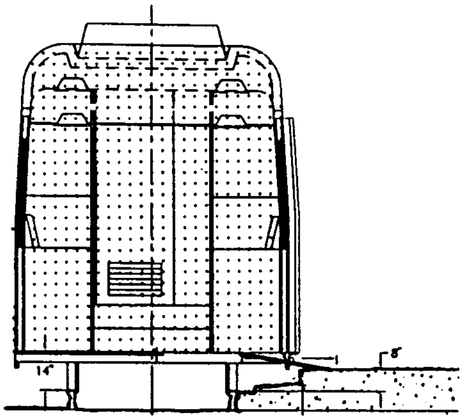
Considering a three car consist (see operational assumption No. 1 below), the following are all possible car mix combinations for a train traveling in either direction:

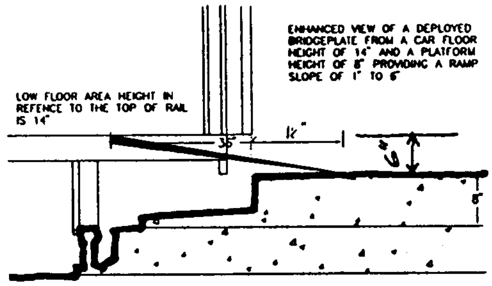


Since accessibility for people with disabilities needs to be provided to the new LFV's only, and given the fact that both Type 7 LRV and LFV have the same overall length, we will consider for this analysis the final stage, i.e. all LFV's. This will simplify the study, while assuring the inclusion of any possible interim combination.

2. *Boarding ramp*

The new LFV cars utilize a deployable ramp and low floor technology to allow boarding by people with disabilities. The ramp is 3 ft. long overall, and goes down 6" from the floor of the car, which is 14" above top of rail elevation, extending 18" outside of the train into the platform.





The existing platforms at all Green Line stations are too low (approximately at top of rail elevation) and therefore their height will need to be increased by ± 8" in order to allow the new LFV to properly deploy the boarding ramp (see diagram).

3. Operational assumptions

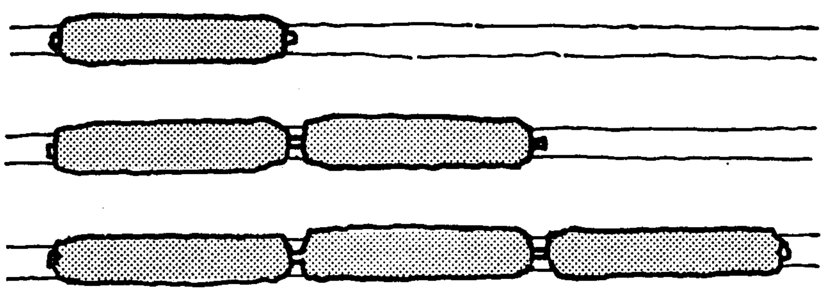
In order to evaluate the impact of the ramp deployment requirements to the accessibility project, some assumptions about the operation of the train were established reflecting MBTA operations criteria:

1. Each train consist, both for Type 7 LRV and LFV cars, will be composed of a maximum of three cars. This will be the case for all four lines (at the present only D line trains use 3 car consists). This analysis will consider every possible combination in order to allow for a total operational flexibility.

1 CAR CONSIST

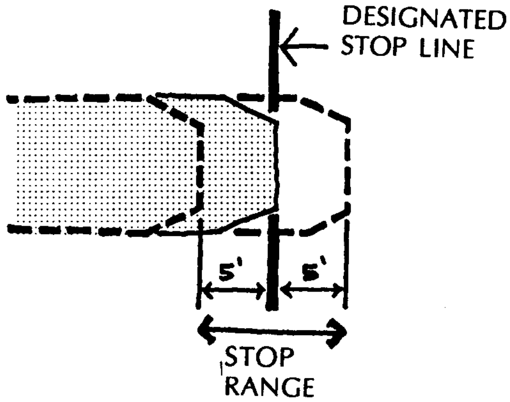
2 CARS CONSIST

3 CARS CONSIST

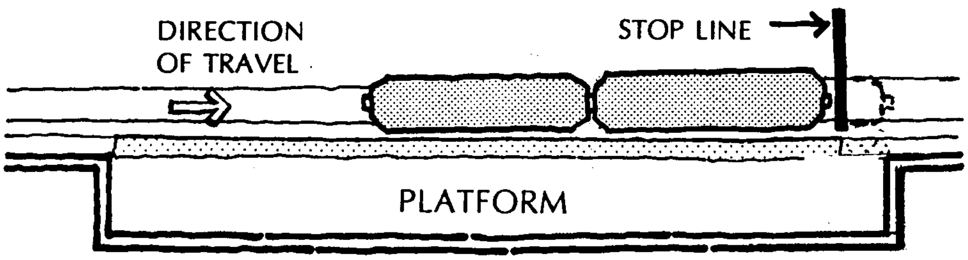


2. The maximum possible number of cars have to be able to board/unboard simultaneously at any given platform, whenever possible, in order to avoid delays.

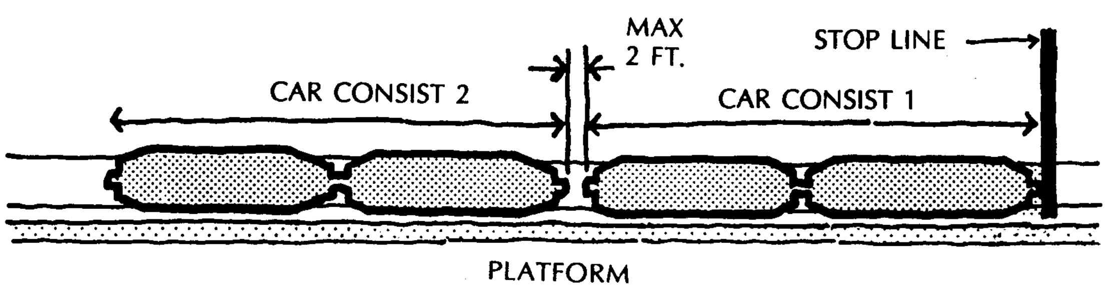
3. The driver of the train consist will stop at the designated platform stop location, or within a maximum distance of ± 5 ft. (5 ft. behind it or 5 ft. beyond it). Therefore, the stop range will be up to 10 ft. long, centered on the designated stop line.



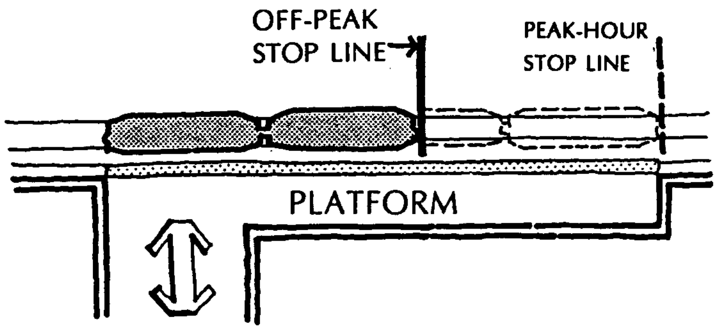
4. In order to assure the optimal utilization of the platform, the designated stop line for the cars entering the station at peak hours will be located as close to the far end of the platform as possible. Allow for exit of front door in relevant cases (depends on direction.)



5. If a train consist enters a station while the previous train is still parked at the station, the second train will stop within 2 ft. from the back of the train in front.

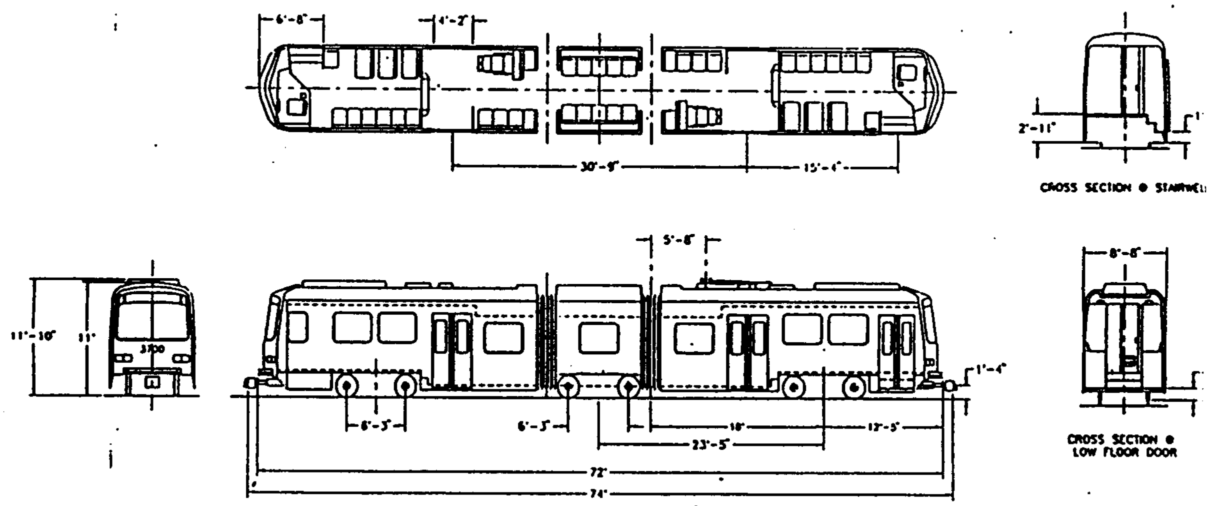


6. Additional stop lines might be designated for off-peak hours, if necessary to bring the passengers closer to central areas of the platform, or closer to main exits/entries. In some cases (such as Park Street Station), where different routes are assigned specific locations at the platform, additional stop locations might have to be designated.



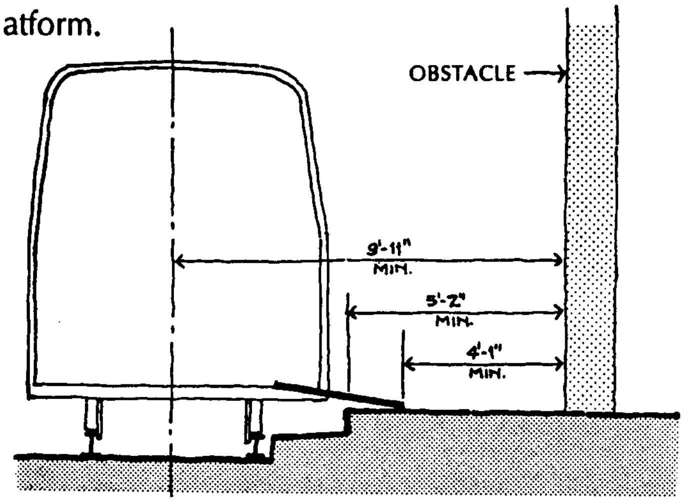
4. *Car description*

The new LFV cars have three doors on each side; one that serves the high floor area, and two central doors that serve the low floor area. These two central doors, equipped with the deployable ramp described above, are the ones that need to be accessible to people with disabilities. These doors are symmetrically located on the center of the car, approx. 30'-9" apart from each other o/c. The following diagram describes the LFV and its main dimensions:



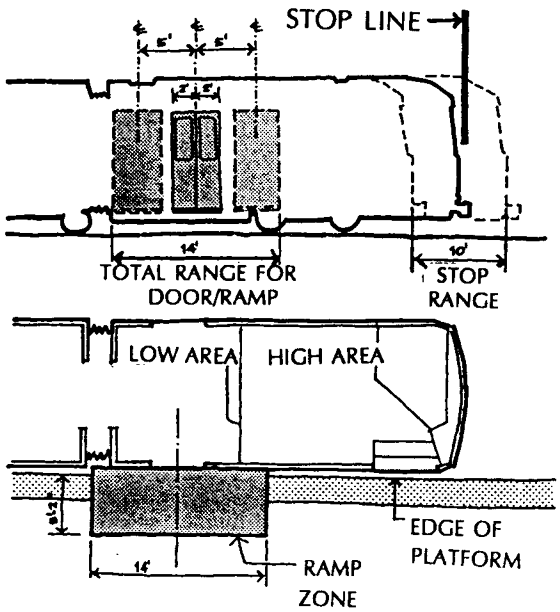
5. *The ramp zone*

In order for the deployed ramp to allow for a wheelchair to maneuver when loading/unloading the train, there needs to be an area clear of any obstacles of at least 4'-0" (5'-0" desired) plus 1" tolerance, in front of it once deployed. The ramp itself will extend 18" beyond the edge of the car, therefore the total depth of the area which needs to be clear (which we will call the "ramp zone") will be 9'-11" (10'-11" desired) minimum from the center line of track, or 5'-2" minimum (6'-2" desired) from the edge of the platform.

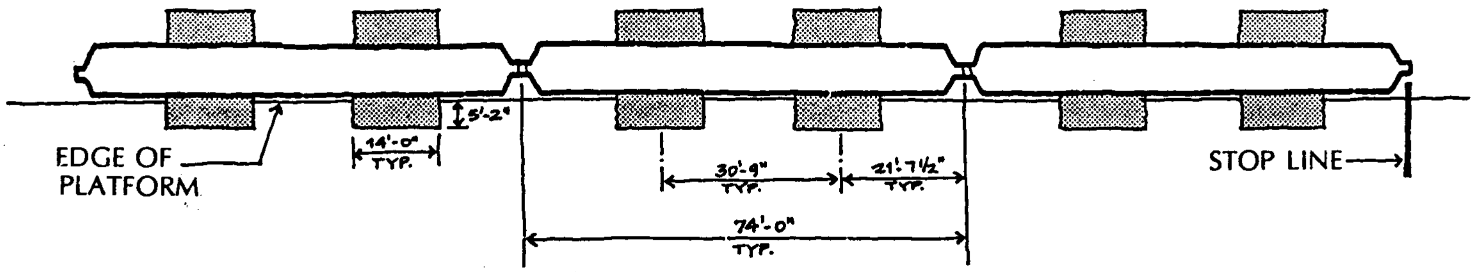


Note: *In the case of a* **curved** *track alignment, the actual distances between the tracks and the edge of the platform will vary depending on the radius of the curve. Therefore, the dimensions described above will have to be adjusted accordingly.*

Considering the stopping range of ± 5 ft. maximum discussed above (operational premise No. 3), and assuming a maximum of 4 ft. ramp width, the total length of the possible ramp locations for one train will be 14 ft., as shown on the following diagram:



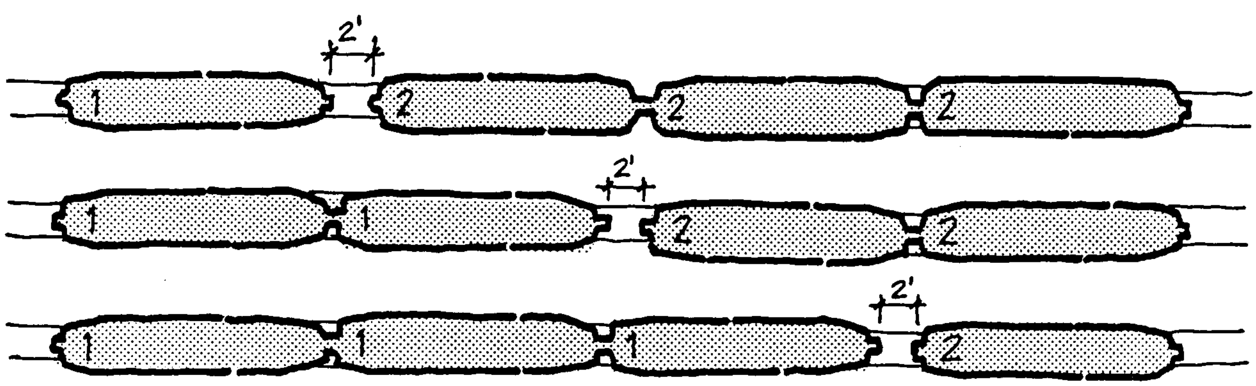
Therefore, the area defined by the ramp zones in front of every accessible door will need to be clear of any obstacle, including structural elements.



Note: *This generic template can be adapted to different* **stop range** *requirements, by reducing or extending the length of the ramp zones accordingly. For example, the 14 ft. long ramp zone with a ± 5 ft. stop range would become 8 ft. long when the stop range is reduced to ± 2 ft., etc.*

6. More than one consist at a platform

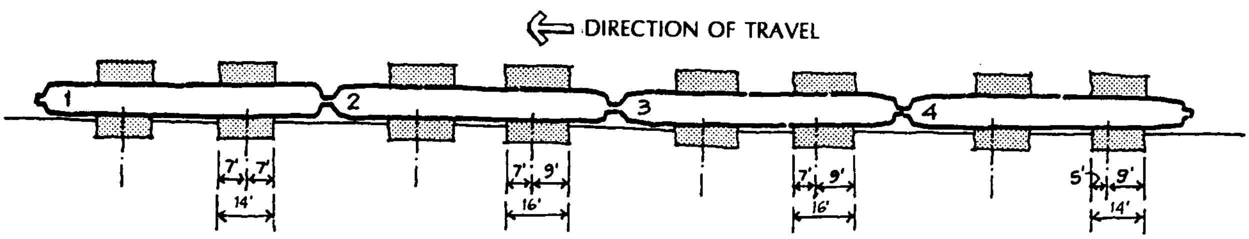
When more than three cars can be accommodated at a platform, the option of operating two car consists simultaneously on the same platform should be provided. In the case of 4 cars on the platform, and considering the 1, 2 and 3 car consists as discussed above (operational premise No. 1), we can summarize all the 3 possible combinations on the following diagram:



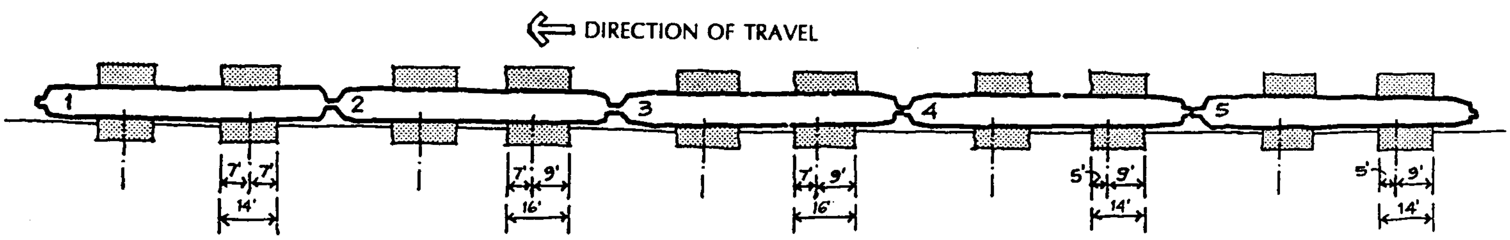
In order to produce a ramp zone diagram for a 4 car platform, the ramp zone diagram for a single car consist shown above should be adjusted, given the 2 ft. distance between car consists mentioned above (operational premise No. 5).

The first car will belong to the car consist in the front in any case. Thus its ramp zones will be the same as in the three cars diagram.
The second and third cars can belong to either the first or the second car consist; therefore we should allow for the extra 2 ft. by extending the ramp zones on these cars.
The fourth car will belong to the second car consist in all cases, therefore the ramp zones on this car should be moved back 2 ft.

The following diagram shows the location and dimensions of the ramp zones for two car consists with up to four cars, assuming a ± 5 ft. stop range:



Note: *For a case in which five cars can fit on a platform, the previous ramp zone analysis remains valid, and a fifth car is added on the back. This fifth car will generate the same ramp zones as the fourth car, given the fact that both cars will always belong to the second car consist.*



7. Use of ramp zone templates

Once the maximum number of cars that fit on a platform has been determined, the appropriate ramp zone diagram can be used to identify the areas on the platform that have to be clear of any obstacle in order for the accessible trains to operate properly.
The use of these diagram as templates by a designer will then synthesize the operational constraints of the new accessible cars, covering both the final stage (all LFV's) and any stage during the interim replacement period as well (any mix of new LFV's and existing Type 7 LRV's).

8. Options for reduction of impacts

As indicated by a preliminary application of this template methodology on subway stations, the impact of the ramp zones suffered by some of the platforms will be very substantial. This impact in some cases (such as Arlington and Park Street) involves extensive structural modifications.
Therefore, it is important to note that a significant reduction of that impact can be achieved by relaxing or modifying some of the operational requirements assumed for this analysis. Some possible steps to consider in that direction include:

1. *Allow for multiple train stopping.* This would reduce the area of the platform to be raised, and in some cases would reduce the number of columns to be impacted by the ramp zones, while maintaining total operational flexibility. However, multiple stopping would increase the time of operation of the train on the platform, causing delays.

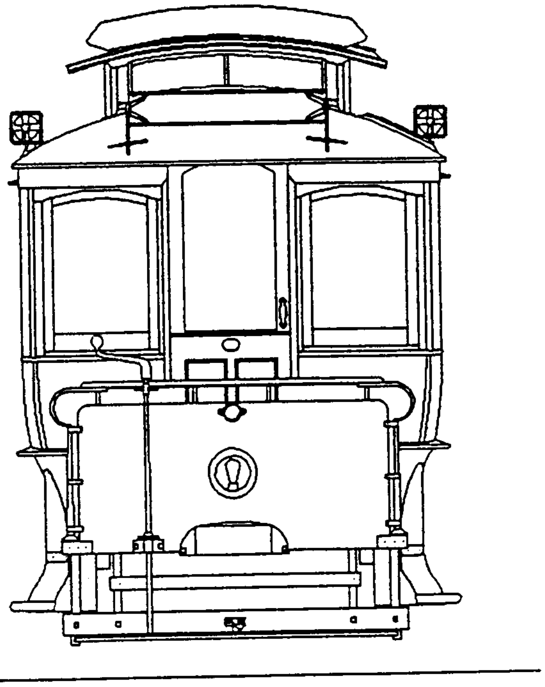
2. *Limit ramp deployment to one car per consist.* The impact of the ramp zones on the platform could be largely reduced by this step, since the ramp zones would be confined to a pre-determined area only. However, this would require a fix location of the LFV within the car consist (i.e. dictate the car mix composition) during the interim period, limiting the operational flexibility.

3. *Limit the ramp deployment to one side of the train only.* In this case the cars would be accessed from both sides, but people with disabilities would be limited to one side only. This step would affect only a few platforms where cars open to both sides, such as Park Street Eastbound platform.

4. *Limit the number of cars operating at the platform.* As discussed on operational assumption No. 2 above, it is required to allow the maximum possible number of cars to operate simultaneously on a platform. Relaxing this rule, however, would in some cases significantly lessen the impact on the platform, since this would effectively shorten the platform (i.e. reduce the amount of ramp zones).

MASSACHUSETTS BAY
TRANSPORTATION AUTHORITY

Low Floor Car Clearance at Platforms



Contributing Departments:
Design & Construction
Operations
Engineering & Maintenance
Rail Vehicle Engineering

October 1994

CADD Drawing by Joseph S. Zen-Ruffinen, Cabot RTL

LOW FLOOR CAR CLEARANCE AT PLATFORMS

Design Division - October 31, 1994

Purpose:

The Federal Government recently passed into law The Americans with Disabilities Act (ADA). This law mandated that all public transportation facilities be made accessible to people with disabilities. For rapid transit lines such as our Red, Orange and Blue lines, which already have high level platforms and level boarding on trains, making stations wheelchair accessible means constructing accessible paths of travel via elevators to get patrons to the platform level. However, for streetcar lines such as our Green Line which have low platform loading along urban streets, and vehicles with raised floors, station and vehicle access for wheelchairs is no easy task.

The major solution to Green Line Accessibility has been determined to be a combination of raised Green Line platforms and low floor vehicles. Based on the design of the new No.8 Low Floor Vehicle it has been determined that platforms should be 8" above top of rail. The purpose of this study was to determine the effect that the 8" platform raise would have on the existing No.7 Green Line Vehicle.

Methodology:

Originally a schematic design was developed for 8" platforms incorporating a 4" intermediate step between door and platform. The low floor car would have a 36" bridge plate extending 18" out to the platform. However the type 7 car would need the intermediate step, especially on curves. This design was incorporated into a computer analysis of type 7 and 8 cars on curves to obtain estimates on platform spacing on curves.

The program used track radius in feet as an input, and applied it to the various vehicle parameters to calculate the appropriate distance between track center and platform edge, and to calculate the gap between the edge of the front and middle doors and the platform edge. This gave the size of the gap a person would have to step over when leaving a car. This information was then used to design a step system between the car step and the platform edge. The program computed gaps at the front and rear of the front doors, and the middle of the middle door, for both the inside and outside of curves for the No.7 and No.8 cars.

To validate the platform design and computer model, the Engineering & Maintenance Department was asked to construct a mock-up of an accessible platform on a tangent, and on a 197 foot radius curve in Riverside Yard. The mock-up had an intermediate 4" step from top of rail to top of the 8" platform. The Rail Vehicle Engineering Department and Green Line personnel furnished a No.7 car with deflated air bags (to simulate a worst case scenario). The car was brought along side the mock-up to obtain field measurements at the doors on the inside and outside of the curve. As a result, a slight adjustment was made in the computer model to account for the fact that the bottom step in the No.7 car is slightly recessed into the car, thus widening the gap about two inches more than previously calculated. With respect to the design, the test showed that the intermediate 4" step was a tripping hazard and that a sloped surface from top of rail to 6" below the top of platform would be a safer alternative. (See attached sketch)

The test also showed that the small metal lower door guide attached to the door panels, which keeps the closed door panels snug against the step, will just make contact with the vertical face of the platform when the doors are open. Therefore it is necessary to cut about 1"to 1-1/2" off these lower door guides so they can clear the platform.

The referenced computer program can now be used to locate the edge of 8" high platforms throughout the Green Line where platforms lie along curves. It was also learned that the location of the platform edge on the outside of curves must be governed by the new No.8 cars but that the platform edge on the inside of curves must be governed by the No.7 car. The middle door of the No.7 car extends further from the center of track than the middle door of the No.8 cars, on the inside of curves.

Conclusions:

The tests indicated than an 8" high platform, 4'9" from centerline of track on tangent, increased on curves to suit the end or middle overhang of existing and proposed cars, does not create any vertical clearance problem with the opened door panels of a No.7 car, even with the air-bags deflated.

The platform edge, at 4'9" from centerline of track on tangent, leaves a gap of 5" from side-sheet of car to platform, and with the No.7 cars, a gap of about 7" between edge of the bottom step and the platform, the same as that on commuter rail coaches. The gap is 3" for rapid transit. As the bottom step is still 5" to 6" above the platform, the horizontal gap is not a problem, but should not be made any larger. Thus the minor modification to the lower door guides is a necessity for continued operation of the No.7 cars with 8" high platforms.

The tests also indicated that it is necessary to fill the space between the rail and the 8" platform edge to provide a surface to step on. The gap at the front of the front door step and the platform with our present LVR's is about 1'5" on tangent, and greater at stations with a platform on the inside of a curve. Thus a paved surface is needed at or near rail level to walk on between the rail and platform. (See attached sketch)

This surface would start flush with the top-of-rail and could slope up toward the platform a maximum rate of 1:12 to a maximum elevation of 2" above top of rail, leaving a 6" step up to the 8" platform. This would not interfere with the snowplows, and with proper surface treatment would not be a slipping hazard. (1:12 is the maximum slope for handicap ramps.) The 4" stepped configuration used in the Riverside tests would not clear the plows and could be a tripping hazard. It was therefore was rejected.

Future Action:

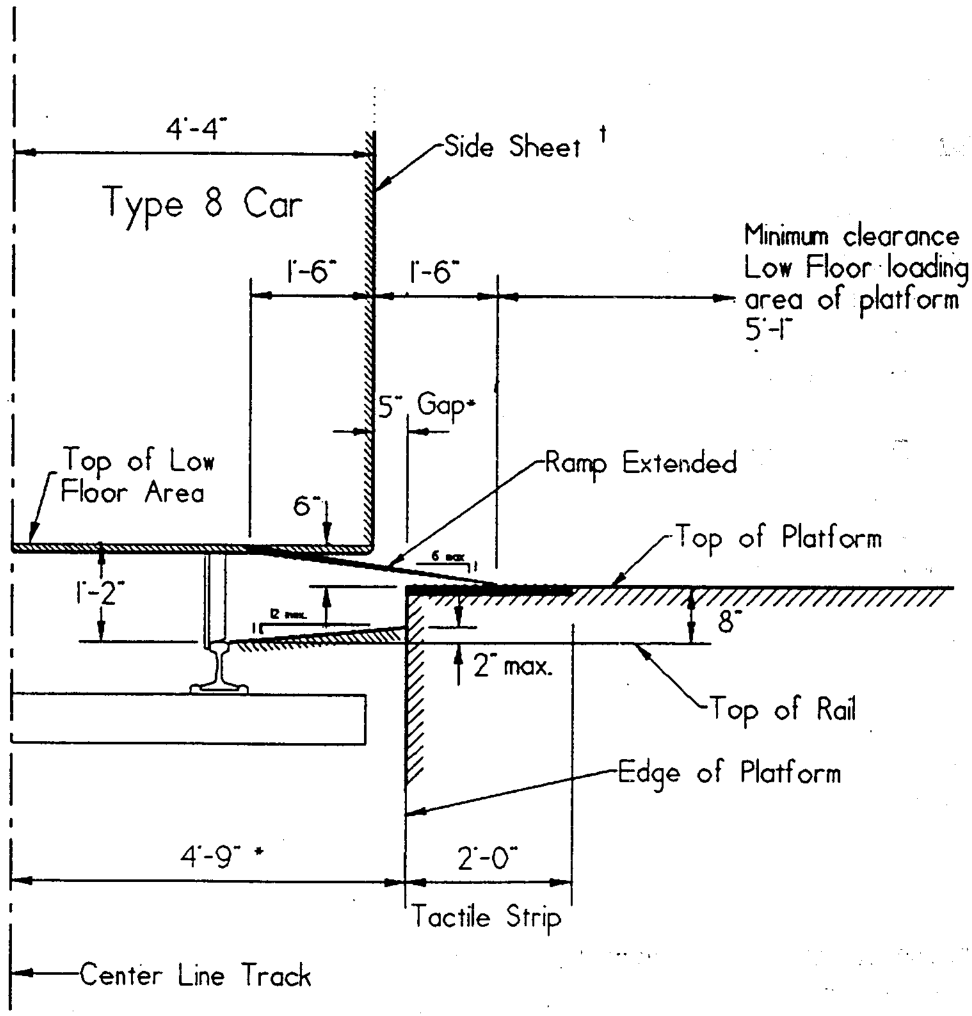
The Program is now at the point now where it is necessary to start positive visible action on the Green Line accessibility program. Since, key stations are supposed to be accessible by mid 1995, the design and construction effort for the Green Line surface stations must accelerate so that construction can be underway during the summer, 1995. The work would include reconstruction of the platforms at 8" above top-of-rail.

The DPW program to reconstruct Commonwealth Avenue between Packards Corner and Warren/Kelton St. is in final design,and will go to bid in spring, 1995. This project involves seven stations, all of which will be built to meet ADA requirements, including 8" high platforms for low floor cars (even though only one of the stations is a key station). The new North Station for the Green Line is now being designed for the 8" high platform, though it will be a number of years before service will start there.

It is obvious that the minor modifications to the No.7 car lower door guide must start quickly to lower the door guide so that these cars can run through stations with 8" high platforms, starting mid 1995.

In addition to the No.7 car issue, it is important that we "hold the line" for specified clearance requirements. All our clearance calculations, including the car/platform clearances are based on this. It is known that the No.8 car end overhang as specified will exceed that of the present cars on certain curves, and it will be necessary to do some field checks of clearance in a timely manner, in case any wayside modifications will be needed to accommodate the new low floor cars.

No. 8 Low Floor Car - Clearance at 8" High Platform



* Note: These numbers shown are for tangent track. they will increase at curved platforms.

† Note: Rub rails. etc. may project beyond this line.

MASSACHUSETTS BAY TRANSPOTATION AUTHORITY DESIGN AND CONSTRUCTION DEPARTMENT DESIGN DIVISION	No. 8 Low Floor Car Clearance at 8" High Platform
	Date: 11-4-94 | By: JIW | No Scale