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# Guide for the Analysis and Design of Reinforced and Prestressed Concrete Guideway Structures

Reported by Joint ACI-ASCE Committee 343

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## Reported by Joint ACI-ASCE Committee 343


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A special acknowledgment is due to M. Y. Riad[*] for his significant contributions to this guide.



*This guide presents a procedure for the design and analysis of reinforced and prestressed concrete guideway structures for public transit, and design guidance for elevated transit guideways. The engineer is referred to the appropriate highway and railway bridge design codes for items not covered in this document.*

*Limit state philosophy is applied to develop design criteria. A reliability approach is used in defining load combinations and deriving load and resistance factors. Different target reliability indexes (4.0 for design strength, 2.5 for serviceability design for cracking, and 2.0 for serviceability design for fatigue) and a service life of 75 years were used as the basis for safety analysis. A 75-year service life is consistent with the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications.*



**Keywords:** cracking; deformation; fatigue; guideway structures; precast concrete; prestressed concrete; prestressing loads; reinforced concrete; vibration.




### CONTENTS




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## CHAPTER 1—INTRODUCTION AND SCOPE

### 1.1—Introduction

The recommendations in this guide provide public agencies, consultants, and other interested personnel with comprehensive criteria for the design and analysis of concrete guideways for public transit systems. They differ from those given for bridge design and analysis in ACI 343R, American Association of State Highway and Transportation Officials (AASHTO) bridge specifications (AASHTO 2002, 2009, 2011, 2012), and the American Railway Engineering and Maintenance-of-Way Association (AREMA) *Manual of Railway Engineering* (AREMA 2012). This document provides guidance related chiefly to the design of guideway superstructures. For the design of substructure units, the reader is referred to other references such as AASHTO LRFD Bridge Design Specifications (AASHTO 2012).

### 1.2—Scope

Design criteria specifically recognize the unique features of concrete transit guideways—namely, guideway/vehicle interaction, rail/structure interaction, special fatigue requirements, and aesthetic requirements in urban areas. Criteria are based on current state-of-the-art practice for moderate-speed (up to 100 mph [160 km/h]) vehicles. Application of these criteria for advanced technologies other than those discussed in this guide requires an independent assessment.

AASHTO LRFD Bridge Design Specifications (AASHTO 2012) and ACI 343R are referenced for specific items not covered in these recommendations, including materials, construction considerations, and segmental construction.

## CHAPTER 2—NOTATION AND DEFINITIONS

### 2.1—Notation

$A$ = exposed area of pier perpendicular to the direction of stream flow, ft$^2$ (m$^2$)
$A_{cp}$ = area enclosed by the outer boundary of cross section, in.$^2$ (mm$^2$)
$A_l$ = area of longitudinal reinforcement in a member, in.$^2$ (mm$^2$)
$A_o$ = lever arm area enclosed by the centerline of the shear flow, in.$^2$ (mm$^2$)
$A_{oh}$ = area enclosed by the centerline of the outermost closed transverse torsion reinforcement, in.$^2$ (mm$^2$)
$A_r$ = cross-sectional area of a rail, in.$^2$ (mm$^2$)
$A_s'$ = area of compression reinforcement, in.$^2$ (mm$^2$)
$A_t$ = area of one leg of a closed stirrup resisting torsion, in.$^2$ (mm$^2$)
$A_v$ = area of shear reinforcement, or area of shear reinforcement perpendicular to main reinforcement for deep beams, in.$^2$ (mm$^2$)
$a$ = center-to-center distance of shorter dimension of closed rectangular stirrup, in. (mm)
$B$ = buoyancy
$BR$ = broken rail forces
$b$ = center-to-center distance of longer dimension of closed rectangular stirrup, in. (mm)
$C_D$ = flowing water drag coefficient
$C_d$ = horizontal wind drag coefficient
$CE$ = centrifugal force, lb (N)
$C_e$ = wind exposure coefficient
$C_g$ = wind gust effect coefficient
$COLFH$ = horizontal collision load, lb (N)
$COLFV$ = vertical collision load, lb (N)
$CR$ = forces due to creep in concrete, lb (N)
$CT$ = collision load, lb (N)
$c$ = clear concrete cover, in. (mm)
$DC$ = dead load, lb (N)
$DR$ = transit vehicle mishap load, due to vehicle derailment, lb (N)
$DW$ = dead load of wearing surfaces and utilities, lb (N)
$d$ = distance from extreme compressive fiber to centroid of longitudinal tension reinforcement, in. (mm)
$d_v$ = distance from centroid of tensile steel to centroid of concrete struts, in. (mm)
$E_c$ = modulus of elasticity of concrete, psi (MPa)
$E_{ci}$ = modulus of elasticity of concrete at transfer of prestress, psi (MPa)
$E_r$ = modulus of elasticity of rail steel, psi (MPa)
$E_s$ = modulus of elasticity of reinforcement, psi (MPa)
$EH$ = loads due to weight and pressure of soil, water in soil, or other material, lb (N)