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Barrier for buildings: analysis of mechanical resistance requirements

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Abstract

Barriers (guardrails and balustrades) prevents people from falling, for example, from balcony, open windows and stairs. Barriers also retain, stop or guide person in buildings. To increase the transparency of these components, traditional materials such as bricks, wood and metal are being replaced by glass or an organic material, which has mechanical behavior different from traditional materials. Regulation usually specify some action to take into account in the design of barriers, but do not define the required resistance. There are no international standards (ISO or EN) to assess the fitness for use of barriers, only national standards, with different testing loading conditions and mechanical resistance requirements. In this paper is presented a comparison of requirements and experimental testing conditions specified in standards from Portugal, Spain, France, UK, USA and Brazil. The goal of this research is to find some equivalence between standards, regarding the mechanical resistance behavior of different materials (brittle/ductile materials) and set a worst case scenario as the basis for the guardrails mechanical resistance profile. Some relations between the service limits state (plasticity) of metal guardrails and maximum deflection are proposed.

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Keywords: GuardRails; Fatigue; Durability; Case Study; Experimental Techniques; Numerical Techniques

1. Introduction

In buildings balconies, terraces, landings, staircase are required elements to give people assess to higher floors or allow people to stay outside at higher levels. This architectural element requires protection to prevent people from

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falling. There are several types of barriers with different types of materials, fillings and fixings (UNE 85-237-91). For example, barriers mainly composed by metallic elements (aluminum, steel and stainless steel), glass, organic materials, wood, concrete or bricks.

To fulfill with safety requirements barriers should comply with requirements related to the minimum height of protection, with maximum openings size and that its components are not easily scalable. The barriers must withstand accidental or involuntary type of actions and their flexibility should be limited to prevent alarming users (BS 6180). Usually the barriers aren't designed to prevent that people can transpose it intentionally, nor are they designed to withstand acts of vandalism.

The assessment of barriers safety could be based on ultimate limit state and serviceability limit state (RSA). The ultimate limit state (ULS) are associated with severe damage, for example, breakage, excessive deformation, instability, cracking and plastic deformation. The serviceability limit states (SLS) are associated with some severe losses, eg not compatible deformation in service conditions, presence of plastic deformation or cracking. The barriers not being a structural element are subject to particular specifications, whose actions are based on static loads specified in codes (RSA and EN 1991) and dynamic loads detailed in technical specification for guardrails, for example BS 6180, NBR 14718, NF-P 01-013, NP 4491, UNE 85-238-91. The technical specifications for the qualification of guardrails typically involve the following characteristic:

- Dimensional characteristics;
- Resistance to horizontal static force (deformation and safety tests);
- Resistance to vertical static force;
- Resistance to dynamic test shock with soft body;
- Resistance to dynamic test shock with hard body;
- Resistance to wind load
- Evaluation of the durability of materials and coatings.

In section 2 is presented a comparison of requirements for guardrails in different technical specification. In section 3 is presented a theoretical and experimental analysis to set limits to obtain the same stiffness for barriers, supported in traditional barriers of steel. In section 4 are presented the main conclusions.

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Nomenclature

δ	Deformation (mm)	P	Punctual load (N)
σ	Stress (Pa)	SLS	Serviceability limit state
σ_y	Yield stress (Pa)	ULS	Ultimate limit state
E	Elastic modulus (Pa)	w	Linear load (N/m)
H	Height (m),	x	Distance from the top of posts (m)
I	Inertia moment (m^4)	y	Distance from the neutral fibre (m)
L	Width (m)		
M	Bending moment (N.m)		

2. Comparison of requirements for mechanical resistance of guardrails and balustrades

2.1. Comparisons of different standards

As detailed previously, there are no international standard for the assessment of guardrail performance despite their importance for the use and safety of buildings. The design and assessment of this building component is done supported by regulation and national standards. In table 1 and 2 are summarized the technical specifications, the proposed actions and loads and the requirements in Portugal (NP standard), France (NF standard and CSTB for guardrail with glass), Spain (UNE standard), UK (BS standard), USA (ASTM – standard) and Brazil (NBR-standard).