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BSI Standards Publication

Plastics piping systems — General rules for structural design of glass-reinforced thermosetting plastics (GRP) pipes

Part 1: Buried pipes

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National foreword

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Part 1: Buried pipes

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Partie 1: Tubes enterré

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Foreword

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This document was prepared by ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, SC 6, *Reinforced plastics pipes and fittings for all applications*.

A list of all the parts in the ISO 20656- series, can be found on the ISO website.

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Introduction

This document provides general rules for structural design of buried glass-reinforced thermosetting plastics (GRP) pipes. It provides the necessary link between the requirements for safety, serviceability and durability of GRP pipe construction products and the technical provisions for civil works. The basis for design of structures, as specified in ISO 2394 and Eurocode EN 1990, are addressed in this document by providing partial factors for effects of actions and resistance for buried GRP pipes.

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Plastics piping systems — General rules for structural design of glass-reinforced thermosetting plastics (GRP) pipes —

Part 1:
Buried pipes

1 Scope

This document describes how partial factors for buried GRP pipes are developed, and are primarily intended to define the necessary safety measures for GRP pipes that meet the requirements of ISO 10639, ISO 10467 and ISO 25780, and EN 1796 and EN 14364. The same methodology can be utilised for other pipe product standards, although other parameters would apply.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2394:2015, *General principles on reliability for structures*

ISO 10639, *Plastics piping systems for pressure and non-pressure water supply — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin*

ISO 10467, *Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin*

ISO 25780, *Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques*

EN 1796, *Plastics piping systems for water supply with or without pressure — Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP)*

EN 1990:2002, *Eurocode — Basis of structural design*

EN 14364, *Plastics piping systems for drainage and sewerage with or without pressure — Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) — Specifications for pipes, fittings and joints*

EN/TS 14632, *Plastics piping systems for drainage, sewerage and water supply, pressure and non-pressure — Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) — Guidance for the assessment of conformity*

3 Terms and definitions

For the purposes of this document the terms and definitions given in ISO 2394 and EN 1990 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

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— ISO Online browsing platform: available at http://www.iso.org/obp

4 Partial factor method

4.1 General

The procedures used here follow the methodology for establishing partial factors for effects of actions and structural resistance as specified in ISO 2394 and EN 1990. The procedure followed is the semi-probabilistic method (ISO 2394:2015, Clause 9 and EN 1990, Clause 6), where characteristic values of actions are defined, and these design values are determined based on the uncertainties involved, both in terms of actions, material properties and environment. The partial factors are the ratio between the characteristic values and the design values. The process consists of minimising the risk involved compared with perceived costs, and defined probability of failure, using level II of the first order reliability method (FORM, Level II).

In this Clause the method is described briefly as it applies for buried flexible pipes. For a full explanation of the methodology, refer to ISO 2394 and EN 1990.

The method for establishing partial factors for resistance is based on ISO 2394, 9.4.2 (with reference to Annex C), as EN 1990, 6.3.3, 6.3.4 and 6.3.5 (with reference to Annex D). The principles are the same in both standards.

4.2 Reliability index, β

The measure of reliability is conventionally defined by the reliability index, β, which is related to the probability of failure, P_f, by:

$$P_f = \times(-\beta) \tag{1}$$

where Φ is the cumulative distribution function of the standardised normal distribution.

The relation between the probability of failure, P_f, and the reliability index, β, is given in Table 1.

Table 1 — Relationship between probability of failure and reliability index

P_f	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
β	1,28	2,32	3,09	3,72	4,27	4,75	5,20

The probability of failure, P_f, is expressed through a performance function, g, such that a structure is considered to survive if $g > 0$ and fail if $g \leq 0$:

$$P_f = \text{Prob}(g \leq 0) \tag{2}$$

where g is the performance function with:

$$g = R - E \tag{3}$$

where

R is the resistance;

E is the effect of actions;

R, E and g are random variables.

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For a normal distribution the reliability index β is:

$$\beta = \frac{\mu_g}{\sigma_g} \tag{4}$$

where

μ_g is the mean value of g;

σ_g is the standard deviation.

We thus have:

$$\mu_g - \beta \times \sigma_g = 0$$

and

$$P_f = \text{Prob}(g \leq 0) = \text{Prob}(g \leq \mu_g - \beta \times \sigma_g).$$

Using this function, the partial factors are established, based on the uncertainties associated with the effects of actions and the uncertainties of resistance.

Since the short-term resistance of plastics is considerably higher than the long-term resistance, the partial factors for effects of actions need to be determined for both cases, i.e. both for incidental actions and sustained actions. Partial factors for resistance are determined for short-term material properties and are converted to long-term material properties as described in Clause 6.

The design value for a normal distribution is (see EN 1990:2002, Table C.3 and ISO 2394:2015, Clause E.6):

$$X_d = \mu - \alpha \times \beta \times \sigma = \mu \times (1 - \alpha \times \beta \times V) \tag{5}$$

where

μ is the mean value;

α is the sensitivity index;

β is the reliability index;

σ is the standard deviation;

V is the coefficient of variation.

Both EN 1990 and ISO 2394 define target reliabilities based on consequences of failure. In addition, the ISO 2394 includes the relative cost of safety measure as part of the assessment. Table 2 shows the consequence classes as defined in EN 1990.

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