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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION •МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ •ORGANISATION INTERNATIONALE DE NORMALISATION

Principles of structural fire-engineering design with special regard to the connection between real fire exposure and the heating conditions of the standard fire-resistance test (ISO 834)

Principes d'ingénierie des structures compte tenu du feu, particulièrement en ce qui concerne le rapport entre l'exposition à un incendie réel et les conditions d'échauffement dans l'essai de résistance au feu normalisé (ISO 834)

FOREWORD

Technical Report 3956 was drawn up by Technical Committee ISO/TC 92, *Fire tests on building materials and structures*, and approved by the majority of its members. It is intended as useful background information to those using International Standard ISO 834, *Fire resistance tests – Elements of building construction*, and should be read in conjunction with that publication.

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0 INTRODUCTION

One of the fundamental aims of carrying out a fire-resistance test on elements of building construction is to obtain results that can be used as data for a structural fire-engineering design which takes into account real conditions. This Technical Report is intended to serve as guidance for facilitating the planning, performance and reporting of a fire-resistance test in conformity with this principle, especially with regard to the connection between real fire exposure and the heating conditions of a standard fire-resistance test according to ISO 834.

The present tendency of building codes and regulations towards more accurately defined functional requirements increases the need for the development of methods for a differentiated structural fire-engineering design. During recent years, several such design methods have been presented in the literature. These methods may generally be assigned to one of two groups according to the basic data on the process of fire development. The methods of the first group (see clause 3) are characterized by a design procedure which is directly based on gas temperature-time curves of the complete process of fire development, specified in detail with regard to the influence of the fire load and the geometrical, thermal and ventilation properties of the fire compartment. Characteristic of the methods of the second group (see clause 4) is a design procedure which takes into account the varying properties of the fire development over an "empirical" time of fire duration related to the standard temperature-time curve. In all methods, the effect of the cooling phase of the fire is included.

1 SCOPE AND FIELD OF APPLICATION

This Technical Report describes the basic characteristics of the process of fire development, and gives principles of structural fire-engineering design based on differentiated temperature-time curves and on an empirical time of fire duration.

2 BASIC CHARACTERISTICS OF THE PROCESS OF FIRE DEVELOPMENT

Irrespective of the group to which the method belongs, a structural fire-engineering design must be based on detailed knowledge of the characteristics of the process of fire development. Although numerous important investigations have been reported in the literature, the present state of knowledge is far from satisfactory in this respect.

In simple terms, fully developed compartment fires exhibit two types of behaviour (see [1]). For the first type, the combustion during the flame phase is controlled by the ventilation of the compartment; the burning rate is approximately proportional to the air supply through the openings of the compartment and is not in any decisive way dependent on the amount, porosity and particle shape of the fuel. For the second type, the combustion during the flame phase is controlled by the properties of the fuel bed; the burning rate is determined by the amount, porosity and particle shape of the fuel and is largely independent of the air supply through the openings. The boundary between the two kinds of fire behaviour is not sharply defined.

For ventilation-controlled fires, the average burning rate of the active part of the fire can be determined for different types of fire load, furniture included, with an accuracy which is sufficient in most practical cases for a structural design. For fuel bed-controlled fires with a more complicated behaviour, the present state of knowledge is too incomplete to permit a satisfactory calculation of the burning rate in practice when the fire load consists of furniture, the porosity properties of which are very difficult to define. In such a case, it seems reasonable at present to base a structural fire-engineering design on characteristics for the process of fire development which have been determined on the assumption that the fire is ventilation-controlled. For fuel bed-controlled fires, such an assumption leads to a fire-engineering design which will be on the safe side in practically every case, giving an over-estimation of the maximum gas temperature level, partly balanced by an under-estimation of the time of fire duration.

An extensive basis of gas temperature-time curves of a fire compartment, determined according to this philosophy, is given in [2] for the complete process of fire development, with varying assumptions concerning the geometrical and thermal characteristics of the room, the opening factor $A\sqrt{h}/A_t$ and the fire load q, where

A is the total area of the window and door openings of the fire room, in square metres;

A_t is the total area of the surfaces bounding the fire room, in square metres;