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Structures for mine shafts —

Part 5: Shaft system structures

Structures de puits de mine —

Partie 5: Structures des réseaux de puits

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 82, *Mining*.

A list of all parts in the ISO 19426 series can be found on the ISO website.

Introduction

Many mining companies, and many of the engineering companies which provide designs for mines, operate globally so ISO 19426 was developed in response to a desire for a unified global approach to the safe and robust design of structures for mine shafts. The characteristics of ore bodies, such as their depth and shape, vary in different areas so different design approaches have been developed and proven with use over time in different countries. Bringing these approaches together in ISO 19426 will facilitate improved safety and operational reliability.

The majority of the material in ISO 19426 deals with the loads to be applied in the design of structures for mine shafts. Some principles for structural design are given, but for the most part it is assumed that local standards will be used for the structural design. It is also recognized that typical equipment varies from country to country, so the clauses in ISO 19426 do not specify application of the principles to specific equipment. However, in some cases examples demonstrating the application of the principles to specific equipment are provided in informative Annexes.

Structures for mine shafts —

Part 5:
Shaft system structures

1 Scope

This document specifies the loads, the load combinations and the design procedures for the design of shaft system structures in both vertical and decline shafts. The shaft system structures covered by this document include buntons, guides and rails, station structures, rock loading structures, brattice walls, conveyance and vehicle arresting structures and dropsets, services supports, rope guide anchor supports and box fronts.

Rock support is excluded from the scope of this document.

This document does not cover matters of operational safety, or layout of the shaft system structures

This document adopts a limit states design philosophy.

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 19338, *Performance and assessment requirements for design standards on structural concrete*

ISO 22111, *Bases for design of structures — General requirements*

ISO 10721-1, *Steel structures — Part 1: Materials and design*

ISO 2394, *General principles on reliability for structures*

ISO 3010, *Bases for design of structures — Seismic actions on structures*

ISO 12122, *Timber structures — Determination of characteristic values*

ISO 19426-1, *Structures for mine shafts — Part 1: Vocabulary*

ISO 19426-4, *Structures for mine shafts — Part 4: Conveyances.*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19426-1 apply.

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

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

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

4 Symbols

A	frontal area of the conveyance (m^2)
a	gap at a joint in a rail (m) (see Table B.2)
B_f and B_w	two sides of the section in Table 3, for aspect 3
b	height difference between two rails at a support to the rails (m) (see Table B.2)
D_n	self-weight of pipe including any lagging (N/m)
d	vertical or lateral differential at a joint in a rail (m) (see Table B.2)
d_i	deformation of the relevant structural component (m).
d_s	depth of the conveyance guide shoe (m)
E_r	emergency rope load
E_p	emergency load on a protective platform
e	maximum moving beam misalignment of the guide (m) (see Table B.1)
e'	modified moving beam misalignment of the guide (m)
F	design load or load effect (N, Nm)
F_B	dynamic load on the platform (kN)
F_F	load on station footwall structures (N, N/m^2)
F_p	load on personnel loading and access platform structures (N, N/m^2)
F_V	vertical load (N)
G_1 and G_2	permanent loads or load effects (N, Nm)
G_b	permanent load applied to brow beams (N, N/m^2)
G_c	conveyance self-weight load (N)
G_p	permanent load applied to pipe supports (N)
G_s	permanent load applied to sidewall support structure (N)
G_y	permanent load on conveyor supports (N)
g	acceleration due to gravity (m/s^2)
H	lateral imposed load (N)
H_f	guide roller load (N)
H_s	lateral slipper plate load (N)
h	overall width or depth of the section or height of the bulk material (m)
h_1, h_2	lever arm distances of the relevant slipper plate loads with respect to the relevant centroidal axes (m)

h_b	height of the ore pass (m)
h_d	height through which the rock falls; to be taken as the depth of the rock pass (m)
I_l, I	mass moments of inertia of the conveyance about the centroidal axes perpendicular to the relevant direction of the slipper plate load (kgm^2)
K	conveyance holding device support load (N)
k_b	lateral stiffness of the steelwork at the guide to bunton connection (N/m)
$\overline{k_b}$	non-dimensional lateral steelwork stiffness at the guide to bunton connection
k_g	lateral stiffness of the steelwork at the guide midspan (N/m)
k_r	roller assembly stiffness (N/m)
L	guide span, bunton to bunton (m)
L_C	member length (m)
L_p	assessed length of pipe supported on the pipe support (m)
$\overline{M}$	guide bending moment coefficient (obtained from Figure 2)
M_g	maximum guide bending moment (Nm)
m_e	proportion of the conveyance mass effectively acting at a slipper plate (kg)
m_r	mass of the largest rock (kg)
m_s	mass of the conveyance (empty or full) including the compensating sheave mass, if applicable (kg)
n	number of wheels on the conveyance
p	surface pressure on the layer of girders (kN/m^2)
P_a	load on arresting structures (N)
$\overline{P_b}$	slipper plate load coefficient (obtained from Figure 1)
P_{d1}, P_{d2}, P_{d3}	loads on station dropsets (N)
p_h	hydrostatic pressure (N/m^2)
P_p	vertical impact load on penthouse structures (N)
Q	conveyance payload (N)
Q_1	dominant imposed load or load effect, or the applied load causing fatigue (N, Nm)
Q_2 to Q_n	additional independent imposed loads or load effects (N, Nm)
Q_e	emergency load or load effect (N, Nm)
R_i	single rock impact load on the box front (N)
r_k	steelwork stiffness ratio = k_b/k_g

r_u	rebound velocity ratio (obtained from Figure 5)
$r_{u.1}$	rebound velocity ratio on the stiffer side (obtained from Figure 5)
$r_{u.2}$	rebound velocity ratio on the less stiff side (obtained from Figure 5)
s	penetration depth into the bulk material (m)
S_f	frequency of guide roller load application (percentage of buntons passed deemed to cause guide roller load application) (see Table B.1)
S_r	frequency of rail impact load application (percentage of rail joints passed deemed to cause rail impact load application) (see Table B.2)
S_s	frequency of slipper plate load applications (obtained from Table B.1)
T	slinging load (N)
T_s	static load applied to slinging anchorage (N)
U	load due to underslung equipment (N)
U_p	impact energy on a protective platform (J)
v	winding velocity (m/s)
W_a	wheel impact load arising from rail joint irregularity (N)
W_l	lateral wheel load acting normal to the rail (N)
W_n	conveyance wheel load acting normal to the rail (N)
Z_i	impact energy of the falling rock (J)
α_a	conveyance impact factor
α_{d1}	conveyance loading impact factor
α_{d2}	rail impact factor due to rail irregularities
α_{d3}	shaft impact factor due to the change in direction from the decline shaft to the station dropset
α_f	hopper door opening impact factor
α_i	proportion of potential energy transferred into impact energy on the box front
α_l	lateral wheel load factor (see Table B.2)
α_n	nominal slipper plate impact factor
α_r	shaft condition factor (see Table B.1)
α_s	sling impact factor
α_w	wheel dynamic factor
α_H	wheel horizontal load factor
β	dynamic load coefficient

β_s	slipper load amplification factor
δ_s	conveyance displacement coefficient (obtained from Figure 3)
γ_e	partial load factor for emergency loads
γ_{f1} to γ_{fn}	partial load factors for imposed loads
γ_{g1} and γ_{g2}	partial load factors for permanent loads
ε_t	transverse rock strain, as defined by rock engineering analysis
μ	friction factor between the hopper payload and the door
ρ	bulk density of ore pass contents, or the bulk density of hopper payload (kg/m^3)
Ψ_1 to Ψ_n	load combination factors
$\varnothing_d$	angle between the horizontal and the shaft decline
$\varnothing_s$	angle between the dropset and the shaft decline
Δ	total lateral displacement of a conveyance (m)
Δ_c	specified clearance between slipper plate and guide (m)
Δ_e	sum of guide gauge and slipper gauge variations, or the rail gauge variations (m) (see Table B.1 and Table B.2)
Δ_{e1}	maximum allowable guide gauge variation (m) (see Table B.1)
Δ_g	lateral guide displacement (m)
Δ_o	overlap allowance (m) which shall be taken as not less than 0,003 m
Δ_w	slipper plate wear (m) (see Table B.1)

5 Materials

Materials used in the construction of shaft system structures should be as specified in EN 197-1 and EN 206-1 for concrete, ISO 10721-1 for structural steel and ISO 12122 for timber. All materials used shall be properly graded materials.

6 Nominal loads

6.1 Permanent loads

6.1.1 Self-weight

Self-weight loads shall be assessed in accordance with ISO 22111.

6.1.2 Brow beams and sidewall support structures

Where required, the permanent load, G_b, applied to brow beams shall be assessed considering the rock over-break but shall be not less than a uniformly distributed load of 20 000 N/m^2. Where fractured or weak rock conditions are encountered, loading shall be specified in consultation with the rock engineer.

The permanent load, G_s, applied to sidewall support structures shall be assessed considering the rock properties and over-break but shall be not less than a uniformly distributed load of 5 000 N/m^2. Where fractured or weak rock is encountered, loading shall be specified in consultation with the rock engineer.

6.1.3 Pipe supports

The permanent load, G_p, applied to pipe supports shall be obtained using the following Formula:

$$G_p = L_p D_n \tag{1}$$

where

L_p is the assessed length of pipe supported on the pipe support. In the absence of better information, the assessed length, for vertical pipes, shall be taken to be the length of pipe from the support below the one in question to the support above the one in question (m);

for horizontal or inclined pipes, the assessed length shall be taken as the length of pipe from the support to the left of the one in question to the support to the right of the one in question (m);

D_n is the self-weight of pipe including any connections and lagging (N/m).

6.1.4 Conveyor supports

The permanent load, G_y, on conveyor supports shall be assessed in accordance with normal conveyor design practice.

6.2 Imposed loads and load effects

6.2.1 General

Shaft system structures shall be designed to resist the imposed loads as assessed in accordance with ISO 22111. In addition, they shall be designed to resist the loads d*efi*ned in 6.2.2 to 6.2.14.

6.2.2 Guide support structures

6.2.2.1 Fixed guides in vertical shafts in shaft zone A (see annex A)

6.2.2.1.1 Lateral imposed loads (H) and maximum guide bending moment (M_g)

It shall be assumed that only one of the loads defined in (a) and (b) below can act at any one time.

a) Guide roller load (H_f):

The load normal to the guide face or the guide sides shall be taken as

$$H_f = k_r \Delta_c \tag{2}$$

where

k_r is the roller assembly stiffness (N/m);

Δ_c is the specified clearance between slipper plate and guide (m).

b) Lateral slipper plate load (H_s):

Slipper plate loads shall be assessed in two directions, namely, normal to the face of the guide and normal to the sides of the guide. These loads shall be assessed for both full and empty conveyances and shall be applied to the guide in the vicinity of the connection to the bunton, considering the action of only one slipper at a time, i.e. it is assumed that the slipper plate load normal to the face of the guide and the slipper plate load normal to the sides of the guide cannot occur simultaneously.

The lateral load between any slipper plate and the guide, H_s (N), shall be taken as:

$$H_s = \alpha_n \left(\overline{P_b} \frac{400 m_e v^2 e}{L^2} \right) \tag{3}$$

The proportion of the conveyance mass effectively acting at a slipper plate, m_e (kg), is:

$$m_e = \frac{m_s I_1 I_2}{\left(I_1 I_2 + m_s h_2^2 I_1 + m_s h_1^2 I_2 \right)} \tag{4}$$

The non-dimensional lateral steelwork stiffness at the guide to bunton connection, $\overline{k_b}$, is:

$$\overline{k_b} = \frac{k_b L^2}{m_e v^2} \tag{5}$$

The steelwork stiffness ratio, r_k, is:

$$r_k = \frac{k_b}{k_g} \tag{6}$$

Where, in Formulas (3) to (6),

α_n is the nominal slipper plate impact factor which in the absence of better information shall be taken as 2,0;

$\overline{P_b}$ is the slipper plate load coefficient (obtained from Figure 2);

m_e is the proportion of the conveyance mass effectively acting at a slipper plate (kg);

v is the winding velocity (m/s) – see Figure 1;

e is the maximum moving beam misalignment of the guide (see Table B.1) (m) – see Figure 1;

L is the guide span, bunton to bunton (m) – see Figure 1;

m_s is the mass of the conveyance (empty or full) including the compensating sheave mass, where applicable (kg);

I_1, I_2 mass moments of inertia of the conveyance about the centroidal axes perpendicular to the relevant direction of the slipper plate load (kg/m^2);

k_b is the lateral stiffness of the steelwork at the guide to bunton connection (N/m);

NOTE See COMRO User Guide No. 21 for a method of incorporating the stiffness of the conveyance into the steelwork stiffness.

k_g is the lateral stiffness of the steelwork at the guide midspan (N/m).