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Knowledge FOr Resilient soCiEty

Building fire protection requirements in Slovakia

University of Zilina

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LECTURE CONTENTS

- SK fire safety system description
- Building categorisation – purpose groups
- Compartments and fire resistance requirements
- Evacuation and means of escape
- Fire separation distances
- Fire protection systems
- Use of fire engineering
- Future objectives

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Brief description of fire safety design system in SK

Slovak republic

The main fire safety regulation is reg. no. 94/2004 which lists most important facts and calls for the various standards, primarily STN 92 0201 parts 1 to 4.

There are other regs and standards for specific occupancies (flammable liquid storage) and specific systems (water for fire fighting).

The system may be described as calculation based in which acceptance criteria eg. FR levels, max. evacuation times, etc. are prescriptively given.

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BUILDING CATEGORISATION – PURPOSE GROUPS

Basic **building categories**:

1. Non-industrial – dwelling and accomodation, assembly, healtcare...
2. Industrial
3. Agricultural production
4. Single storey warehouses
5. Open technological equipment (plant)
6. Open storage
7. Technological bridge

Fire classification further specified through:

- Fire risk level (calculated)
- Construction type (combustibility)
- Building height

There are **5 fire classes** (fire protection degrees) which determine fire resistance requirements for construction elements.

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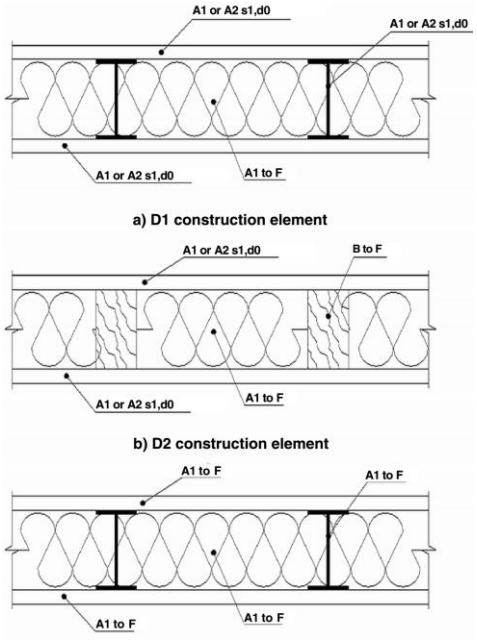
BUILDING CATEGORISATION – CONSTRUCTION ELEMENT AND SYSTEM TYPES

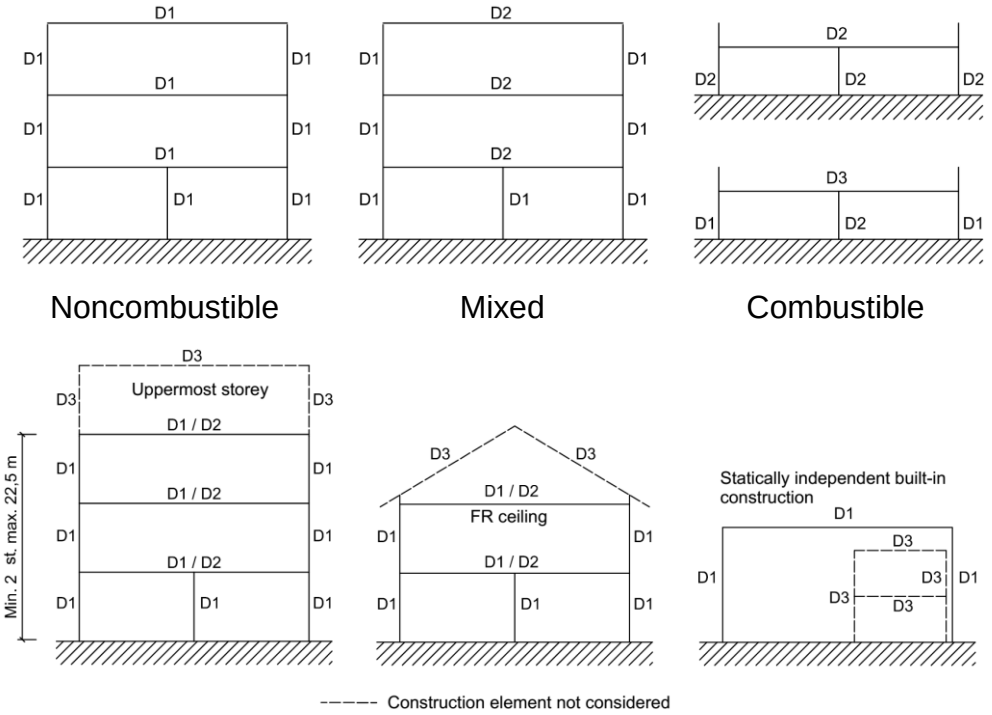
Construction element types

Based on reaction to fire classes of building materials constituting the elements and their composition.



Construction system types

Based on the types of fire resisting and load-bearing construction elements constituting the system. Important for building height restrictions.



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BUILDING CATEGORISATION – FIRE RISK LEVEL

FIRE RISK

Probable fire severity in the fire compartment (average fire load) or its part (localised fire load). A major parameter for FR requirements.

Fire risk is expressed in:

- Calculated fire load p_v **[kg.m^{-2}]** for non-industrial buildings
- Equivalent fire duration τ_e **[min]** for industrial and agricultural build.
- Stored materials index i_p **[-]** and economic risk index i_e **[-]** for single-storey warehouses

For industrial and non-industrial buildings fire risk is calculated taking into account various parameters such as the level of fire load, type of combustibles and compartment ventilation.

Single storey warehouses calculations are more coefficient-based.

For car parks fire risk depends on type, size and whether above or underground.

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Building categorisation fire – Fire classes of compartments

Non-industrial buildings - general

Construction system	Fire risk - calculated fire load in fire comartment kg.m^{-2}	Lowest allowed fire class of fire compartment				
		I.	II.	III.	IV.	V.
		Building height *h* less than m				
noncombustible	≤15	22,5	not restricted			
	> 15 ≤ 30	12	30	not restricted		
	> 30 ≤ 45	6	22,5	45	not restricted	
	> 45 ≤ 60	6	12	30	45	not rest.
	> 60 ≤ 90	0	6	12	30	45
	> 90 ≤ 120	0_a	0	6	12	30
	> 120*)	N_1	0_a	0	6	12
mixed	≤ 10	12	12	18	22,5	N_2
	> 10 ≤ 25	6	12	18	22,5	N_2
	> 25 ≤ 35	6	12	18	22,5	N_2
	> 35 ≤ 50	0	6	18	22,5	N_2
	> 50 ≤ 75	0	6	12	22,5	N_2
	> 75 ≤ 100	0_a	0	6	12	N_2
	> 100*)	N_1	0_a	0	6	N_2
combustible	≤ 10	9	9	9	9	N_2
	> 10 ≤ 20	4	9	9	9	N_2
	> 20 ≤ 30	4	9	9	9	N_2
	> 30 ≤ 40	0	4	9	9	N_2
	> 40 ≤ 60	0	4	4	9	N_2
	> 60 ≤ 80	0_a	0	4	4	N_2
	> 80*)	N_1	0_a	0	4	N_2

Industrial and agricultural production

Number of storeys	Lowest allowed fire class of fire compartment				
	I.	II.	III.	IV.	V.
	$\tau_e \cdot k_8$ or $\overline{\tau_e} \cdot k_8$ or $\tau_{em} \cdot k_8$				
≤ 2	≤ 45	≤ 75	≤ 90	> 90	–
> 2	≤ 30	≤ 60	≤ 90	≤ 120	> 120

Multi dwellings and blocks of flats

Construction system	No. of storeys above ground level	Lowest allowed fire class of fire compartment	
		AGF + I. UGF	II. UGF and below
noncombustible	3 8 16 over 16	I II III IV	II III IV V
mixed	2 3	I II	not allowed
combustible	1 2	I II	not allowed

A separate system for parking garages.
No fire clases for single st. warehouses.

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FIRE RESISTANCE REQUIREMENTS

All building types except warehouses

	Ref.	Purpose of construction element	Minimum required FR and type of construction element based on fire class					Construction importance coefficient k_9
			I.	II.	III.	IV.	V.	
Multi-storey buildings	1.	Fire-separating constructions (walls, partitions and ceilings):						
		a) underground storeys,	45/D1	60/D1	90/D1	120/D1	180/D1	1,3
		b) above-ground storeys,	30	45	60	90	120	1,0
		c) uppermost storey.	30	30	45	60	90	0,5
	2.	Fire doors, shutters and hatches in fire-separating constructions:						
		a) underground storeys,	30/D1	45/D1	45/D1	60/D1	90/D1	-
		b) above-ground storeys,	30/D3	30/D3	45/D3	60/D1	90/D1	-
		c) uppermost storey.	30/D3	30/D3	30/D3	45/D3	60/D1	-
	3.	Exterior walls:						
		a) loadbearing						
		1. underground storeys from interior side,	45/D1	60/D1	90/D1	120/D1	180/D1	1,3
		2. above-ground storeys,	30	45	60	90	120	1,0
		3. uppermost storey,	30	30	45	60	90	0,5
		b) non-loadbearing	30[3)]	30[3)]	45[3)]	60[3)]	90[3)]	0,5
	4.	Roof loadbearing constructions without fire-separating function	30	30	45	60/D1	90/D1	0,5
	5.	Interior loadbearing constructions						
		a) underground storeys,	45/D1	60/D1	90/D1	120/D1	180/D1	1,3

FR requirements are based on purpose of construction element and fire class of compartment.

FR of **load-bearing** elements in lower storeys shall not be less than in upper storeys – if fire classes are lower then FR must be increased.

FR requirements can be reduced with sprinkler system; indirectly through fire load parametres reduction in calculations.

FR requirements for single-storey warehouses

Ref.	Fire-separating constructions	Stored materials index i_p			
		≤ 1,0	> 1,0 ≤ 2,0	> 2,0 ≤ 4,0	> 4,0
		Minimum required FR and type of construction element			
1	Fire walls and ceilings including their supporting loadbearing construction	30/D1	90/D1	120/D1	180/D1
2	Fire doors, shutters and hatches	30/D3	45/D1	60/D1	90/D1
3	Exterior walls	30	60	90	120

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Fire compartment size restrictions

Non-industrial based on max. floor size and max no. of floors in compartment

$$S_{\max} = \frac{1250 - 2020 \ln a}{c_{\text{const}}(c_{\text{storey}} + n_{\text{storey}})}$$

Determining combustibles type (a) construction system (c_{const}), above or underground (c_{storey}) and no. of storeys (n_{storey}).

$$z_{\max} = \frac{c_{\text{const}}}{p_{\text{v}}}$$

Determining construction system (c_{const}) and calculated fire load (fire risk p_{v}).

Carparks restrict $S_{\max}$ or no. of parking spaces based on vehicle type, parking arrangement, construction system type, height, above/underground and ventilation.

Industrial much more complex, taking into account combustibles type ($P_{2\max}$), economic loss (p_2), no. of storeys (k_5), construction system (k_6) and indirect fire loss (k_7).

$$S_{\max} = \frac{P_{2\max}}{p_2 . k_5 . k_6 . k_7}$$

Single-storey warehouses based on stored materials index i_{p} – $S_{1\max}$, ranging from 200m^2 / i_{p} = 8,0 to nonrestricted / i_{p} < 1,0.

Apart from carparks it is possible to increase $S_{\max}$ when fire protection systems are present; most significant with sprinkler systems.

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EVACUATION – GENERAL PRINCIPLES

SK system is a ASET/RSET based system, where ASET limits are prescribed (tabulated) and RSET is calculated. General acceptance criterion $t_u \leq t_{u,max}$.

$$t_u = \frac{0{,}75 \cdot l_u}{v_u} + \frac{E \cdot s}{K_u \cdot u}$$

l_u – max. travel distance

v_u – walking speed

E – no. of occupants

s – evacuation conditions (mobility, MoE type, total/staged)

K_u – MoE width unit (0,55 m) capacity

u – min. available no. of MoE unit widths

MoE type		maximum allowed evacuation time *) $t_{u\ max}$ in min	
		single MoE	multiple MoE
Unprotected MoE in non-industrial buildings with coefficient *a*	≤ 0,6 **)	2,5	4,0
	0,7	2,3	3,7
	0,8	2,0	3,3
	0,9	1,7	3,0
	1,0	1,3	2,7
	1,1	1,0	2,0
	> 1,1	1,0 ***)	1,3
Unprotected MoE in industrial buildings with probability p_1	≤ 0,55 **)	3,0	5,0
	1,2	2,5	4,0
	2,7	1,5	2,5
	> 2,7	0,75	1,5
Partially protected MoE	Type 1 and 3 (fully FR separated)	4,0	6,0
	Type 2 (15 min FR separated)	3,0	4,0
Fully protected MoE	Type A	6,0	10,0
	Type B	15,0	20,0
	Type C	30,0	30,0

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Evacuation – number of MoE, maximum travel distances and minimum widths

By default two independent MoE are required, unless <100ppl (fewer if under-ground or immobile) are present. Max. distance between room/compartment exists and MoE stairs is 60m.

Maximum travel distance l_{ud} and minimum MoE width u_{min} are just variations of the basic RSET (t_u) formula.

$$l_{ud} = \frac{v_u}{0{,}75}\left(t_{ud} - \frac{E \cdot s}{K_u \cdot u}\right)$$

$$u_{min} = \frac{E \cdot s}{K_u\left(t_{ud} - \frac{0{,}75\, l_u}{v_u}\right)}$$

Minimum MoE width:

- Absolute 0,55m (1 u)
- Partially or fully protected MoE 0,825m (1,5 u) / 0,8m doorway
- 1,65m (3 u) when bedbound/immobile persons are present

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EVACUATION – TYPES OF ESCAPE ROUTES

There are three types of escape routes:

1. **Unprotected** – no fire separation, ventilation or fire protection systems required
2. **Partially protected** – fire separation required, no ventilation or fire prot.
3. **Protected** - fire separation (full FR) and ventilation required
   - **Type A –** min. natural ventilation 2m^2 per storey, no lobbies or emergency lighting
   - **Type B** – min. natural ventilation 2m^2 per storey, ventilated lobbies, emergency lighting
   - **Type C** – positive pressure ventilation to stairs and lobbies, emergency lighting

In buildings over 60m all escape routes must be Type C protected escape routes.

Number of escape routes	Minimum required type of protected escape route					
	above ground storeys			underground storeys		
	building height h_{pv} in metres					
	≤ 22,5	> 22,5 ≤ 45,0	> 45,0	≤ 4,5	> 4,5 ≤ 8,0	> 8,0
first (single)	A	B	C	A	B	C [1)]
further (multiple)	A	A	B	A	A	B

SEPARATION DISTANCES – GENERAL PRINCIPLES

Separation distances are based on whichever is higher:

1. Heat radiation
2. Falling burning parts

Heat radiation separation distances are calculated using intensity of fire (fire risk (p_v, τ_e, i_p), area of radiating surfaces, height and width of fire compartment.

Falling burning parts separation distances are calculated as 0,36 * building *h*.

Radiating surfaces are **fully, partially and roof radiating** depending on FR of exterior walls and combustibility of their external finish/cladding.

Eg. Windows have zero FR therefore, they are considered fully radiating surfaces, polystyrene wall insulation above 10cm is considered partially radiating surface, despite the wall meeting the FR criteria (% of wall is counted as fully radiating).

Separation distances can be indirectly **reduced with sprinklers** and have to be **increased** when **building has a mixed or combustible construction system**.

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SEPARATION DISTANCES – EXAMPLE TABLE

Table 3 – Fire separation distances in m for compartment height h_u= 3 m

Length l_u m	% fire radiat. surface	p_v in kg.m^{-2} or τ_e in min.									
		≤ 10	20	30	40	50	60	80	100	120	≥ 180
≤ 4,5	100	2,5	3,5	4,0	4,4	4,7	5,0	5,4	5,7	6,0	6,7
	80	2,1	2,9	3,5	3,8	4,1	4,4	4,7	5,0	5,3	5,9
	60	1,5	2,3	2,8	3,1	3,4	3,6	4,0	4,2	4,5	5,0
	40	0,2	1,5	1,9	2,3	2,5	2,7	3,0	3,2	3,4	3,9
	20	0,0	0,0	0,0	0,7	1,0	1,2	1,5	1,8	1,9	2,3
9,0	100	3,1	4,5	5,3	5,9	6,3	6,7	7,3	7,8	8,2	9,1
	80	2,5	3,7	4,5	5,0	5,4	5,8	6,4	6,8	7,2	8,0
	60	1,7	2,8	3,5	4,0	4,4	4,7	5,2	5,6	5,9	6,7
	40	0,3	1,7	2,3	2,8	3,1	3,4	3,8	4,2	4,4	5,1
	20	0,0	0,0	0,0	0,7	1,1	1,4	1,8	2,1	2,3	2,8
12,0	100	3,3	4,8	5,8	6,5	7,0	7,5	8,2	8,8	9,2	10,3
	80	2,6	4,0	4,8	5,5	6,0	6,4	7,0	7,6	8,0	9,0
	60	1,7	3,0	3,7	4,3	4,7	5,1	5,7	6,2	6,6	7,4
	40	0,3	1,7	2,4	2,9	3,2	3,6	4,1	4,5	4,8	5,5
	20	0,0	0,0	0,0	0,8	1,1	1,4	1,8	2,1	2,4	2,9
15,0	100	3,4	5,1	6,1	6,9	7,5	8,0	8,8	9,5	10,0	11,3
	80	2,6	4,1	5,1	5,8	6,3	6,8	7,5	8,1	8,6	9,7
	60	1,7	3,0	3,9	4,5	5,0	5,4	6,0	6,6	7,0	8,0
	40	0,3	1,8	2,4	2,9	3,3	3,7	4,2	4,6	5,0	5,9
	20	0,0	0,0	0,0	0,8	1,1	1,4	1,8	2,1	2,4	3,0

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Fire protection systems requirements: sprinkler systems and fire alarm

Sprinkler system is required in:

- accommodation parts in hotels for more than 300 guests
- accommodation parts in other accommodation buildings for more than 500
- in-patient (bed) wards of healthcare buildings for more than 800 persons
- exhibition halls over 5000 m^2 if they form single fire compartment
- retail premises compartment over 1000 / 2000 m^2 (multi / single-storey bldg)
- theatre stages in theatres for more than 500 (with flies) / 800 persons

Fire alarm system is required in:

- accomodation buildings for more than 20 guests with combustible or mixed construction system; 50 guests with non-combustible construction system
- healthcare buildings with in-patient (bed) wards
- assembly buildings (over 200 persons)
- underground storeys where over 20 persons are present
- car-park fire compartments for with more than 50 parking spaces

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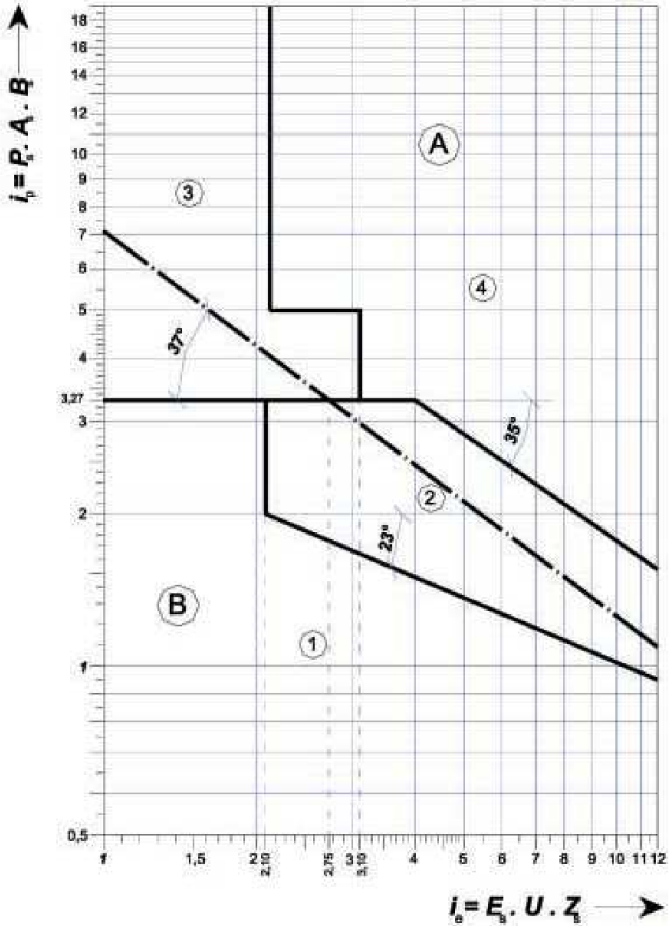
Fire protection systems requirements: single-storey warehouses

System requirements based on risk level i_p and i_e

1. no fire protection system required
2. fire detection and alarm with automatic link to fire brigade
3. fire sprinkler system
4. fire detection and alarm with automatic link + fire sprinkler

A. (above dashed line) smoke control system required

B. (below dashed line) smoke control system not required



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Fire protection systems requirements: voice alarm and smoke control systems

Voice fire alarm is required in:

- accomodation buildings for more than 20 guests with combustible or mixed construction system; 50 guests with non-combustible construction system
- where staged evacuation is assumed
- in all building types with occupancy over 200 persons except dwelling (even when automatic detection is not required)

Smoke control system is required in:

- protected means of escape and firefighter access routes
- assembly areas (over 200 persons)
- multi-storey underground fire compartments (each floor less than 1000 m^2)

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Fire fighting features requirements: access roads, hard standings, FF shafts

Access roads required for all buildings except for remote and difficult access locations. Access roads must go max. 30m (50m single dwelling) away from bulidings.

Hard-standings required for all buildings unless:

- building height is less than 9m
- building has internal fire-fighter shafts and access
- it is not possible to conduct fire-fighting operations from exterior
- buildings with all compartments with very low fire risk
- buildings without access roads

Fire-fighting shafts are required in buildings:

- with building height less than 22,5m if they are deeper than 30m if access is possible from one side only; 60 m in other cases
- with building height over 22,5m
- irrespective of height if it is not possible to conduct fire-fighting operations from exterior (through windows)

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Fire fighting features requirements: FF lifts, mains, hydrants and extinguishers

Firefighting lifts are required in all buildings over 60m and industrial buildings where high fire risk areas are located above 22,5m level.

FF lifts must be located in the lobbies of Type B or C protected escape routes.

Dry risers are required in each firefighting shaft in buildings over 30m.

Wet risers are required in each firefighting shaft in buildings over 60m.

Fire hydrants are required in all buildings except for:

- dwelling houses – one to three dwelling units
- buildings or their parts where water is not allowed for fire fighting
- in fire compartments where the product of fire load and compartment floor area (p.S) is less than 10 000.

Fire extinguishers are require in all buildings except for dwelling houses – one to three dwelling units. No. of extinguishers based on fire growth coeff. and compartment floor area (in multi-storey compartments each floor separately).

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Fire safety engineering – performance based design option

At the moment the SK legislation and standards do not allow any alternative approach to what was briefly presented.

In certain cases more detailed calculation method may be used, however, their benefit is limited given the effort required, e.g. energy balance equation.

Discussions are going on about introduction of FSE, but with limited success.

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Difficulties, future objectives and conclusions

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The system is difficult to use; same approach for a single-dwelling house and shopping centre – one size cannot fit all.

The combination of overlapping clauses in regulations and standards causes difficulties in updating them and incompatibility – law should set general principles and standards calculation methods, values and tech. specifications.

SK needs to introduce more design alternatives and differentiate from simple prescriptive all the way to FSE.

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Case study

Multi occupancy administrative and retail building

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Building description

- 3 – above ground storeys; no underground
- building height 7,42m (floor to floor level)
- 1st storey insurance company and administrative premises
- 2nd and 3rd storey unspecified retail premises
- Construction type – concrete and light plasterboard partitions, glazed façade
- Two staicases and one liftshaft
- Type of building: general non-industrial

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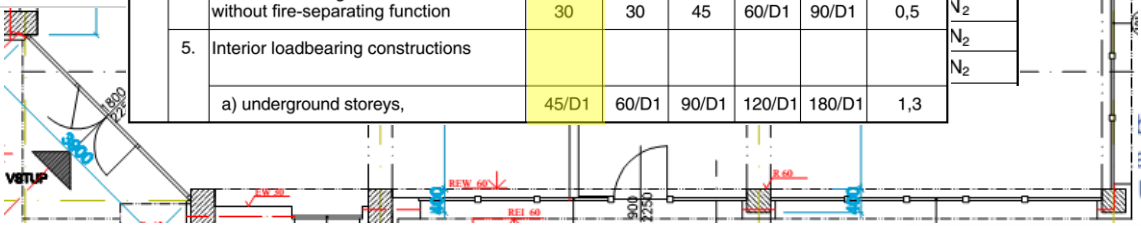
Example of fire risk calculation and fire class determination – 1st storey

Ref.	Room	Area S_i (m^2)	St. ref.	random FL p_n ($kg.m^{-2}$)	fixed FL p_s ($kg.m^{-2}$)	$(p_{ni} + p_{si}).S_i$	combust. a_n	coeff. a_s	$(p_{ni} . a_{ni} + p_{si} .a_s).S_i$	Compart. N1.01	I. fire class
4	Insurance comp.	103.13	8.5.1	25	5	3093.9	0.9	0.9	2784.51		
5	Hallway	13.1	1.1						75.92		
6	Cleaners closet	4.1	16						.48		
7	Office	10.9	1.1						.20		
8	WC - women	4.6	16						.85		
9	WC - men	4.4	16						.23		
10	Stationery storage	17.9	1.1						.72		
11	Office	103.4	1.1						.08		
12	WC - employees	4.4	16						.75		
13	Hallway	3.0	1.1						.40		
									2.1		
		46.3								3	storeys
										337	m^2
										9	storeys
										1	storeys

Multi-storey buildings

Ref.	Purpose of construction element	Minimum required FR and type of construction element based on fire class I.	II.	III.	IV.	V.	Construction importance coefficient k_9
1.	Fire-separating constructions (walls, partitions and ceilings):						
	a) underground storeys,	45/D1	60/D1	90/D1	120/D1	180/D1	1,3
	b) above-ground storeys,	30	45	60	90	120	1,0
	c) uppermost storey.	30	30	45	60	90	0,5
2.	Fire doors, shutters and hatches in fire-separating constructions:						
	a) underground storeys,	30/D1	45/D1	45/D1	60/D1	90/D1	-
	b) above-ground storeys,	30/D3	30/D3	45/D3	60/D1	90/D1	-
	c) uppermost storey.	30/D3	30/D3	30/D3	45/D3	60/D1	-
3.	Exterior walls:						
	a) loadbearing						
	1. underground storeys from interior side,	45/D1	60/D1	90/D1	120/D1	180/D1	1,3
	2. above-ground storeys,	30	45	60	90	120	1,0
	3. uppermost storey,	30	30	45	60	90	0,5
	b) non-loadbearing	30[3)]	30[3)]	45[3)]	60[3)]	90[3)]	0,5
4.	Roof loadbearing constructions without fire-separating function	30	30	45	60/D1	90/D1	0,5
5.	Interior loadbearing constructions						
	a) underground storeys,	45/D1	60/D1	90/D1	120/D1	180/D1	1,3



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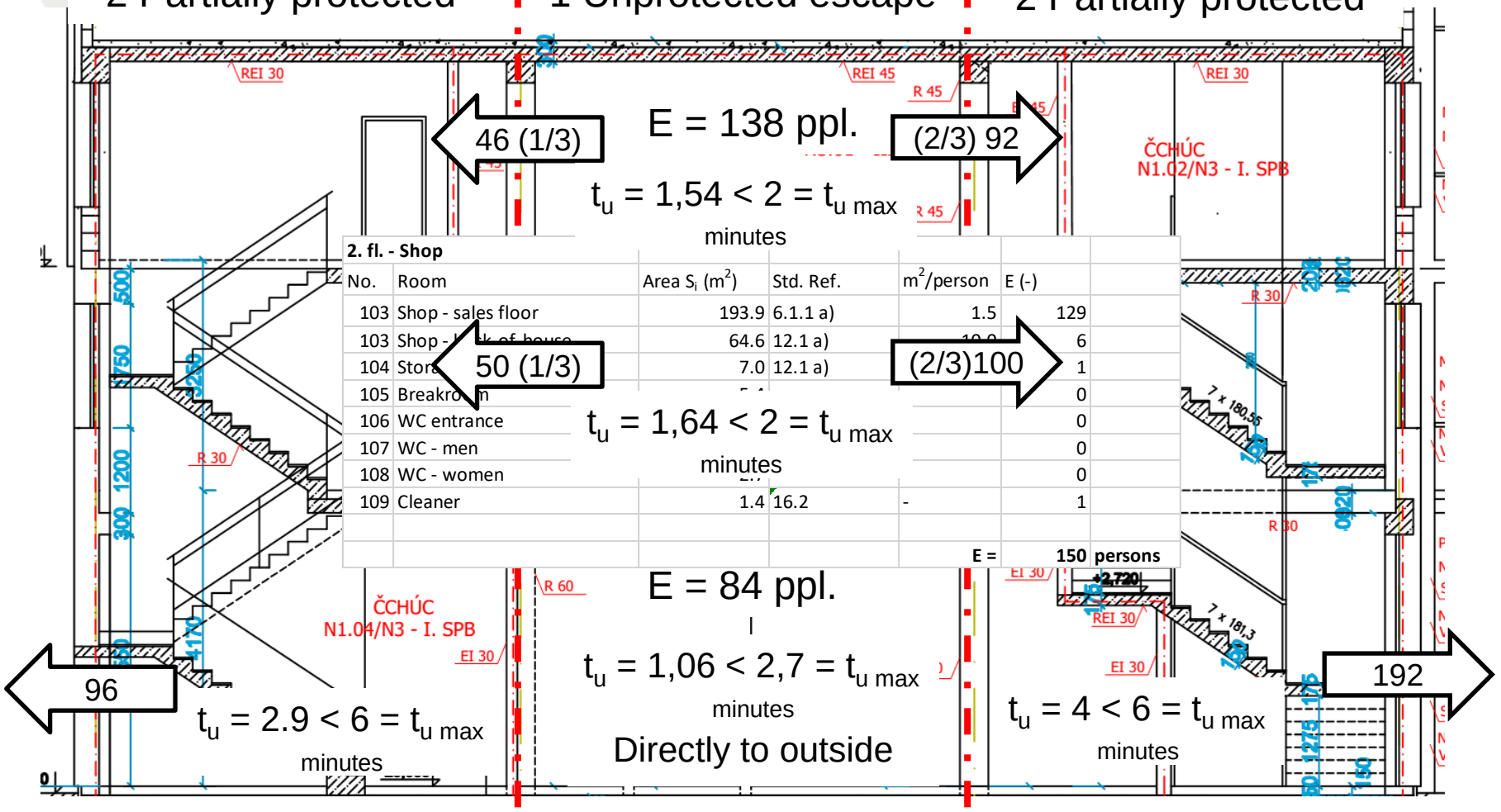
Example of evacuation calculation



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Questions?

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