The new European Standard for civil engineering works

CEN/TC 242 - Safety Requirements for Passenger Transportation by Rope
WG G - Civil Engineering Works
Draft pr EN 13107

By

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In early 1991 the Working Group G (WG G) of Technical Committee 242 (TC 242) met in Oslo for the first time to commence work on the harmonization of codes relating to civil engineering works in the context of ropeway construction.

Since then, the Draft Standard pr EN 13107 has evolved in an ongoing process, based on the comments, objections and revisions which have resulted from the WG G's many meetings held at various different venues.

At the beginning of 1998 the draft standard was submitted to the members of the CEN for comment in the form of a questionnaire.

If the draft becomes a European Standard the CEN members will then be required to fulfil the CEN/CENELEC standing orders which set forth the conditions under which this European standard is to be given the status of a national standard without any form of amendment.

The CEN has issued the draft standard in three official languages (German, English and French).

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The CEN members are the national standards organizations of Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Sweden, Switzerland, Spain, and the UK.

STANDARDS PROGRAM

The European Standard has been prepared by CEN/TC 242 “Safety requirements for passenger transportation by rope”, the Secretariat of which is held by France (AFNOR), at the suggestion of its Working Group G “Civil engineering works”.

This European Standard forms part of the standards program adopted by the CEN Technical Board in relation to safety requirements for passenger transportation by rope. This program includes the following standards:

1	Safety requirements for passenger transportation by rope Terminology	pr EN 1907
2	Safety requirements for passenger transportation by rope General provisions	pr EN 12929-1 : 1997
3	Safety requirements for passenger transportation by rope Calculations	pr EN 12930
4	Safety requirements for passenger transportation by rope Ropes	pr EN 00242004
5	Safety requirements for passenger transportation by rope Tensioning devices	pr EN 1908
6	Safety requirements for passenger transportation by rope Mechanics	pr EN 00242006
7	Safety requirements for passenger transportation by rope Carriers	pr EN 00242007
8	Safety requirements for passenger transportation by rope Electrical devices	pr EN 00242008
9	Safety requirements for passenger transportation by rope Civil engineering works	pr EN 13107 : 1997
10	Safety requirements for passenger transportation by rope Pre-commissioning inspection, maintenance and operational checks	pr EN 1709
11	Safety requirements for passenger transportation by rope Recovery and evacuation	pr EN 1909
12	Safety requirements for passenger transportation by rope Operation	pr EN 12397
13	Safety requirements for passenger transportation by rope Quality Assurance	pr EN 12408

All these standards form an integrated whole with regard to the design, manufacture, execution, maintenance and operation of cableways intended for the transportation of passengers.

SCOPE

The European Standard specifies the safety requirements applicable to civil engineering works for installations for passenger transportation by rope. Its requirements are to be met by taking into account the various types of installations and their environment.

It includes requirements relating to the prevention of accidents and work safety.

It does not apply to installations for the transportation of goods, nor for inclined lifts.

This European Standard is applicable to:

- new cableways;
- significant alterations of existing cableways.

This European Standard is not only intended for the consideration of civil engineers but also for that of other categories of users, such as:

- all experts involved in the design of cableways;
- clients, e.g. for the formulation of their specific requirements on design working life or durability;
- public authorities.

NORMATIVE REFERENCES

The European Standard incorporates the provisions of the various Structural Eurocodes listed below.

STRUCTURAL EUROCODES

EN 1991	Eurocode 1:	Basis of design and actions on structures
ENV 1992	Eurocode 2:	Design of concrete structures
ENV 1993	Eurocode 3:	Design of steel structures
ENV 1994	Eurocode 4:	Design of composite steel and concrete structures
ENV 1995	Eurocode 5:	Design of timber structures
ENV 1996	Eurocode 6:	Design of masonry structures
ENV 1997	Eurocode 7:	Geotechnical design
ENV 1998	Eurocode 8:	Design provisions for earthquake resistance of structures
ENV 1999	Eurocode 9:	Design of aluminum alloy structures

The European Standard gives guidance, together with European Standard pr EN 12929-1: 1997 “General Provisions” and all other standards mentioned above, on the design, manufacture, execution and maintenance of ropeways intended for the transportation of passengers.

For some of the member states, such as Austria and Germany, the fundamental principles on which the Eurocodes are based will mean a new way of thinking with regard to civil engineering safety concepts. The old deterministic method using allowable stresses will be replaced by a semi-probabilistic concept of reliability based on ultimate limit state and serviceability limit state.

Combining the provisions of this pr EN with current national standards may lead to erroneous design.

LIMIT STATES

Before designing a structure, the client and the designer must elaborate a utilization plan. This must specify the serviceability requirements by standard or by agreement.

Design situations for a structure must take into account the special climatic circumstances which may be found in the mountains. That means e.g. that the probability of the simultaneous occurrence of climatic effects such as wind actions, snow loads, ice loading, must be studied carefully.

The verification of the ultimate and serviceability limit states as well the verification of fatigue is to be carried out according to the relevant Structural Eurocodes.

The effects of actions are to be clearly defined for their communication to other parties involved in the design process. Unless specified otherwise, the effects of actions arising from their characteristic values is to be considered for the verification of ultimate and of serviceability limit states.

COMPARISON WITH NATIONAL STANDARDS:

As well as presenting the draft standard “Safety requirements for passenger transportation by rope - civil engineering works”, this paper attempts to identify the differences and overlap with existing standards (e.g. OITAF, Swiss Standards, Austrian Standards).

	CEN	OITAF	Austria	Switzerland
National standard for passenger transportation by rope	prEN 13107	The “Technical Recommend-ations” of the international ropeway organization	-Ropeway Code 1957 (SBB 1957) -Ropeway Code 1976 (draft !!!) (SBB 1976) -Regulations on the construction and operation of chair lifts (edition 1996) -Building permission requirements for specific lifts	Chair Lifts -Code Circulating Ropeways -Code Reversible Aerial Ropeways -Code Funicular Railways -Code
National codes	Eurocodes	Standards applicable in the country where the lift is to be installed; if non-existent, those applicable in the manufacturer’s country	ON	SIA

	CEN	OITAF	Austria	Switzerland
Safety concept	-Semi-probabilistic method -Safety analysis: reliability differentiation -Utilization plan safety plan -Quality assurance : prEN 12408	Depends on national standards of the country where the aerial ropeway is installed	Deterministic method	-Semi-probabilistic method -Utilization plan -Safety plan
Design working life	50 years for aerial ropeways 100 years for funiculars			see utilization plan
ACTIONS				
Permanent actions				
Self-weight	ENV1991 Mass of the structural elements Self-weight of unmovable, non-structural elements	Mass of the structural elements Self-weight of unmovable, non-structural elements	ON B4011 : Mass of the structural elements ON B4012 : Self-weight of unmovable, non-structural elements	Mass of the structural elements SIA160 : Self-weight of unmovable, non-structural elements
Ground actions	ENV1997 Earth loads as well as pore water pressure	National standards	ON B4434 Soil pressure calculation Weight of backfill on foundations	SIA160

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Variable actions				
Actions induced by ropes and carriers	-Carrying-hauling ropes -Track and haulage ropes -Tension ropes -Recovery ropes -Evacuation ropes -Signaling ropes prEN 12930 Calculations	-Carrying-hauling ropes -Track and haulage ropes -Tension ropes -Recovery ropes -Evacuation ropes -Signaling ropes	-Carrying-hauling ropes -Track and haulage ropes -Tension ropes -Recovery ropes -Evacuation ropes -Signaling ropes	-Carrying-hauling ropes -Track and haulage ropes -Tension ropes -Recovery ropes -Evacuation ropes -Signaling ropes
Dynamic effects	-<u>Perpendicular</u>: Percentages of character-istic values of empty or loaded carrier: **Monocable**: 100% for depression towers 50% for support towers **Bicable**: 20% for towers -<u>Longitudinal</u>: 50% of load on one sheave for depression towers 25% for support towers **Funicular**: Axle loads multiplied by a factor of 1.3		All forces induced by the rope when the lift is in operation +30% <u>Grip impact in rope direction</u>: -Support towers: 25% of max. sheave load -Depr. towers: 50% of max. sheave load	-<u>Perpendicular</u>: Percentages of character-istic values of loaded carrier: 100% for depression towers; 50% for support towers. -<u>Longitudinal</u>: In addition, in the case of depression towers, a longitudinal force with the value of the max. sheave load

	CEN	OITAF	Austria	Switzerland
Friction effects	Friction coefficients are given in prEN 12930	As a rule, 3% of total sheave loads	As a rule, 3% of total sheave loads	Haul ropes: Percentage of sheave loads: -lined sheaves: 3%; -unlined sheaves:1%; -lined carriage wheels: 2%; -in rope catcher: 30% of rope action Track ropes: 15% of rope action: ++/+-/-+/--
Imposed loads on service platforms Horizontal line force on railings	-Distributed: 2kN/m² or -Concentrated: 2kN 0.8kN/m	National standards	According to 1996 regulation -Distributed: 2.5kN/m² or -Concentrated: 1.2kN. Horizontal line force on railings to SBB 1957 : -for public circulation areas: 1.2kN/m; -machine rooms and platforms: 0.4kN/m	SIA 160 -Distributed: 2kN/m² or -Concentrated: 2kN
Wind actions	$Fw=q_{ref}c_e c_f c_d A_{ref}$ ENV1991-2-4		ON B4014	$Q=c\ c_{red}c_{dyn}c_h qA$
	Dynamic coeff. $c_d<1,2$		Shape factors: $c_{rope}>=1,2$ $c_{chair}>1,2$	Dynamic coeff. cd=1 (up to 1.9)
				Reduct. coeff. cred=1
				Height coeff. $c_h=1$ up to 2
In operation	$q_{ref}c_e c_f c_d=0,25$ kN/m²	$q_{ip}=0.2$kN/m²	$q_{ip}=0.8$kN/m²	$q_{ip}=0.25$kN/m²
Out of operation	q_{ref} see wind map ENV1991 or national	$q_{aop}=1.2$kN/m² or (v>150km/h) national	$q_{aop}=1.3$kN/m² or national institutes or	$q_{aop}=1.0$kN/m² for ropes and carriers;

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	institutes or bodies min 1.2kN/m²	institutes or bodies	bodies	for spans over 400m, the reduced length: l_{red}=240+0.4l can be used; for stations and towers: wind map in SIA160
Snow loads	ENV1991-2-3 or national institutes or bodies	National standards, national institutes or bodies	ON B4013 or national institutes or bodies	SIA160 or specified by the client and the designer in consultation with competent national institutes or bodies
Ice loading	Specified by the client, designer in consultation with competent bodies or institutes with annual probability of exceedance 0.02	National standards, national institutes or bodies	ON B4013 or national institutes or bodies	Thickness of ice coating: 25mm specific weight of ice: 6kN/m³ wind pressure : 1kN/m² wind coefficient: 1.3
Forces due to drive and braking system	prEN00242006 Mechanics prEN12930 Calculations			
Tensioning, lifting, pulling down	prEN12930 Calculations prEN1908 Tensioning devices		No mention - but have to be considered	

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Action against buffers (normal)	Shock of counterweight or a tensioning carriage, shock of carrier prEN00242006 Mechanics			
Accidental actions				
Action against buffers (extreme)	Shock of counterweight or a tensioning carriage, shock of carrier prEN00242006 Mechanics			Shock of counterweight or a tensioning carriage, shock of carrier with factor 1.1
Wind actions out of operation on unloaded carriers (with detach. grips)	Characteristic values are given in prEN12930 Calculations		Do not constitute an accidental case!	Do not constitute an accidental case!
Carrier track rope brake	Characteristic values are given by the carrier designer			Reversible aerial ropeway code
Blocking grips	Characteristic values are given in prEN00242007 Carriers		Calculated sliding resistance of grip (however, not currently mandatory)	
Deropement	Design values are given in prEN12930 Calculations.	No mention - but have to be considered	Factor 2.0 rope load with factor 1.0 friction (μ=0.2) in rope catcher (however, not currently mandatory)	with factor 1.3
Total relief	Design values are given in prEN12930		No accidental case for de-pression tower : maintenance !	with factor 1.1
Severance of signal cable	Design values are given in prEN12930	have to be considered in one span	No mention - but have to be considered	with factor 1.1
Avalanches	Design values	have to be	have to be	have to be

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and falling stones	are specified by the client and designer in consultation with competent bodies or institutes	considered if relevant. Values are specified in consultation with competent bodies or institutes	considered if relevant. Values are specified in consultation with competent bodies or institutes	considered if relevant with factor 1.1. Values are specified in consultation with competent bodies or inst.
Seismic actions	Design values are given in ENV1998 Design provision for earthquake resistance	National codes	ON B4014	SIA160 (4 19)
Shock of vehicles	Design values are specified by the client and designer in consultation with competent bodies or institutes			National institutes or bodies (BAV)
Fire	Design values are given in ENV1991-2-2 Actions on structures exposed to fire	Fire hazard is to be reduced to a minimum; building materials to be selected accordingly.	ON B3800	SIA160 (4 17)
Other actions and effects	-therm. actions -shrinkage -creep -relaxation -moisture -support displacements -installation -repair		Acc. to 1996 chair lift regs: loadfactor 4.0 standard ice load for telephone lines to ÖVE-L1	National institutes or bodies (BAV)

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Safety factors	see tables 1, 2 and 3 of prEN 13107 following Eurocodes 1-9 **Foundations** : Ed,dst<Ed,stb	**Steel**: related to yield: in operation 2.0 out of op. 1.5 accidental case 1.3 **Concrete**: in accordance with national codes where wind actions have to be increased by 20% **Foundations** : against overturning, sliding and lifting : in op : 1.5 out of op : 1.2	Global safety factor in accordance with national ON standards steel : B4600 concrete:B4200 timber : B4100 etc. Ground: B4430 Safety factor against overturning, sliding and lifting: min. 1.5 Towers : Overturning : in op.: min. 1.5 out of op. :min. 1.2 (with carriers on the line)	The combination of actions is regulated in : Chair Lift, Circulating Ropeway, Reversible Ropeway, Funicular Railway Codes SIA161 SIA162 etc. Safety factor against overturning, sliding and lifting: min. 1.5 Towers: in operation the bottom faces of tower foundations must be subjected to 100% compression
Deflections	Buildings : see ENV's 1992-95; Bridges : L/800 Towers: displacements in operation : support : H/300 depr.: H/500 out of op. H/100 rotations : in op. 0.003rad	Towers : rotations due to torque : 0.003rad	Towers : in operation : transverse: d/4*n n: No. of sheaves per side d: rope Ø in rope dir.: support : H/250 depr.: H/500 measured on front sheave (excl. grip impact with wind q=300N/m²)	Towers : displacements in operation : support : H/300 depr.: H/500 out of op.: H/100 rotations : in op.: 0.003rad out of op.: 0.0175rad
Verification of fatigue	Fatigue loading: Variation of rope actions on and/or the	National standards	ON B4600 Part 3 DIN 15018 ENV1993	Fatigue verification is necessary for: top of support towers,

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	passage of carriers over towers and similar structures of aerial ropeways; The passage of carriages over bridges and similar structures of funicular rail-ways; **Dynamic coefficients**: 1.2 for support, 2.0 for depression and combined towers. Verification to ENV 1993			complete depression towers; quality level QB for welding (SIA161) verification to SIA 161

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Type of construction				
Concrete	ENV1992 table 4.1 Exposure classes related to environmental conditions **Particular attention to:** -aggregates and admixtures -transportation -low temp. -construction joints -finishing -min. surface reinforcement area for plain or lightly reinforced concrete foundations: 300mm²/m	National standards	ON B4200 According to SBB 1957, the use of guyed towers is prohibited, irrespective of execution (steel, concrete, etc.)	SIA162 minimum quality of concrete: B35/25
Steel	ENV1993 corrosion protection !! Min. thickness : open section : 4mm hollow sections: 3mm **Steel grade:** B for bolted or riveted structures C for welded	National standards. Corrosion protection: Required thickness: open section: 4mm hollow sections: 2.5mm	ON B4600	SIA161 Min. thickness : open section : 4mm hollow sections: 3mm **Steel grade:** B for bolted or riveted structures. C for welded

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	structures D or DD for welded structures in some cases. -A steel member is to be connected at each end with at least **2 bolts.** -For structures subjected to fatigue, the use of pre-loaded bolts is strongly recommended.			structures. -For bolted structural elements which are subjected to rope tension and/or drive moment the use of pre-loaded bolts is obligatory. -A steel member is to be connected at each end with at least **2 bolts**. -For structures subjected to fatigue, any holes must be drilled.
Composite Timber Geotechnical	ENV 1994 ENV 1995 ENV 1997	Nat. standard Nat. standard Nat. standard	ON B4500 ON B4100 ON B4430	

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Construction works	Ground anchors -Efficient corrosion protection. -Must be possible to replace or supplement ground anchors. -Accurate and conscien-tious monitor-ing of deform-ation must be possible.		Soil and rock anchors in accordance with ON B4455	Soil and rock anchors in accordance with SIA191 and national bodies
Seismic design	ENV 1998	Nat. standard	ON B4015	SIA 160
Foundations	ENV1992 ENV1997 Particular focus on: -frost penetration -drainage -settlement Friction effects between lateral surfaces of the foundation and the ground as well as resisting earth pressure are to be disregarded.	Concrete foundations to be made of reinforced concrete if necessary. Upper surface of concrete foundation must project above surrounding ground.	Concrete foundations to be made of reinforced concrete if necessary (exception: glacier towers) Friction effects between lateral surfaces of the foundation and the ground as well as resisting earth pressure are to be disregarded. Safety factor against over-turning, sliding and lifting: in op.: min. 1.5	Particular focus on: -frost penetration -drainage -settlement Friction effects between lateral surfaces of the foundation and the ground as well as resisting earth pressure are to be disregarded. Safety factor against over-turning, sliding and lifting: min. 1.5

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			out of op.: min. 1.2 (with carriers on the line)	Towers: in op., bottom faces of tower founds must be subjected to 100% compression
Maintenance Inspection Servicing Repair Renewal	Permanent observation, periodic inspections (periods are given in prEN13107 Section 12). Procedure and extent of servicing determined by the results of inspection. Procedure and extent of repair determined by the results of inspection. May be required after: -extraordinary events -extensive wear and tear or -whenever an important increase in capacity is intended.	Major inspection once a year in accordance with manufacturer's instructions. Once a month: -inspection of line incl. towers and sheave assemblies. Once a week: -drive brakes	see : **transport regulations** and **operating manual** for the specific lift	Civil engineering works: after initial start-up, welds to be checked for surface flaws, rivets and bolts for tight seating/ tightening torque. After 1 year: -crack indications -deformation -wear -tightening torque and securing elements of bolts -towers and foundations for frost damage. Long-term: -as above every 2 years; -every 6 years: anchors, structural movement.
Work safety				