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IS 5230 (2003): Continuous to and Fro Movement Bicable Ropeways Intended for the Transportation of Passengers - Code of Practice for the Construction [MED 6: Continuous Bulk Conveying, Elevating, Hoisting Aerial Ropeways and Related Equipment]

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“Knowledge is such a treasure which cannot be stolen”
Indian Standard

CONTINUOUS TO AND FRO MOVEMENT BICABLE ROPEWAYS INTENDED FOR TRANSPORTATION OF PASSENGERS — CODE OF PRACTICE FOR CONSTRUCTION

( First Revision )

ICS 45:100; 77.140.65

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee had been approved by the Mechanical Engineering Divisional Council.

This standard was first published in 1969. This revision has been undertaken to incorporate modifications based on the technology being followed in the country.

An aerial ropeway is a special form of transportation system where passengers/materials are carried above the ground. A ropeway uses a tensioned wire rope supported above the ground. Aerial ropeways are particularly useful in regions where the facility in surmounting natural barriers gives them a great advantage over railways or roads, both of which may need the heavy civil engineering work to secure easy gradient. They are inexpensive to maintain; their power demand is modest and they are not seriously affected by adverse climatic conditions.

There are two main types of aerial ropeways: monocable and bicable. The choice of a particular type depends upon the length and topography of the route, the type and intensity of the traffic, and in many cases, the relative inaccessibility of the site. The bicable ropeway consists of two stationary carrying ropes; these being parallel to one another and held under tension above the ground with towers suitably positioned. Under favourable conditions spans of 300 m are possible. The vehicles have carriers with wheels arranged to run on the two fixed ropes, a separate endless moving rope is used to haul the carriers along these fixed rope, the moving rope being driven and tensioned as in the case of the monocable system. The carriers are provided with mechanical grips, which automatically attach and detach themselves from the moving rope when the carriers are leaving from or arriving at the terminal stations. The terminal stations have fixed rails on which the carriers can run, these rails being structural prolongation’s of the fixed ropes along the route, and usually arrange to provide a connecting loop, between the incoming and outgoing ropes. The propulsion of the carriers along the station rails is usually mechanized by a prolongation of the haulage rope or by a separate slow-speed rope if the containers have to be loaded. Bicable ropeways are used where rope gradients are considerable and where capacities are high. Very heavy individual loads can be carried because the carrying ropes can be increased in size without materially affecting the haulage rope.

A list of related standards has been given in Annex A for information.

In the preparation of this standard, considerable assistance has been derived from the ‘Recommendations Techniques Relatives A La Construction De Telepheriques Du System A Va-Et-Vient Destines Au Transport Public Des Voyageurs — 1960 (Technical recommendations for the construction of to and fro bicable ropeways for public transport of passengers), issued by Organization Internationale des Transports a Cable (International Organization for Aerial Ropeways Transport) (OITAF).
Indian Standard
CONTINUOUS TO AND FROM MOVEMENT BICABLE ROPEWAYS INTENDED FOR TRANSPORTATION OF PASSENGERS — CODE OF PRACTICE FOR CONSTRUCTION
(First Revision)

1 SCOPE
1.1 This standard covers the construction of continuously moving monocable ropeways with fixed grips intended for the transportation of passengers.
1.1.1 Nothing in this standard is intended to contravene any provisions of the statutory regulations wherever they are in force.

2 TERMINOLOGY
For the purpose of this standard, the following definitions shall apply.

2.1 Ropeway
The system of overhead ropes on which carriers are used for the purpose of carriage of passengers, animals or goods and includes trestles, ropes, carrier, stations, offices, machinery and other works used for the purpose of or in connection with such aerial ropeway.

2.2 Inspecting Authority
Duly authorized representative of the purchaser or any other competent authority recognized by the statutory regulations to inspect the aerial ropeway installation and determine its acceptability or otherwise, on the basis of this standard.

3 GENERAL DESIGN
3.1 Rules for the Construction of Installations
3.1.1 Parts of the ropeway equipment shall be correctly designed and constructed. The quality of the materials to be used for its construction shall be carefully chosen.
3.1.2 On the request of the supervising authority or the purchaser, a certificate of a recognized testing laboratory shall be supplied by the constructor as regards the characteristics of all material used and characteristics essential to the safety of the installation.

3.2 Layout and Freeway
3.2.1 The axis of the line in plan shall be straight. When it is not possible, obtain a straight line, the maximum deviation permitted shall be 0.5 percent.
3.2.2 The clearance of the line shall be determined taking into account the cabin dimensions as well as its lateral oscillations due to maximum wind envisaged in 3.9 and from the departure which results on the sag and displacement of the carrying and haulage ropes. A safety margin of 1.5 m shall be provided for obstacles outside the line.
3.2.3 All the trestles shall be equipped with guides, which limit the transverse oscillations of the wire rope towards the pylon to 6° to 8°. For the maximum inclination permitted by a guide, no part of the vehicle shall touch the shoes or any other part of the trestle.
3.2.4 The two tracks of the ropeway shall be so arranged that the minimum free space which separates vehicles inclined towards each other by 12° is at least 1 m, when the span of the rope is not greater than 300 m. As far longer spans, the clearance shall be increased by 0.2 m for each additional 100 m or part thereof.
3.2.5 In the case of spans where the vehicles do not cross each other or in the case of an installation having only one track and with an endless haulage rope, the clearance measured in the horizontal direction between the wire rope and the vehicle oscillating through 12° in the direction of this rope shall be at least 1 m when the span of the wire rope is not greater than 300 m as far longer spans, this clearance shall be increased by 0.3 m for each additional 100 m or part thereof.
3.2.6 In the longitudinal direction, provisions shall be made for the vehicle inclination of about 35 percent with reference to the vertical.
3.2.7 The minimum vertical clearance between the space occupied by vehicle and the terrain lying below with obstacles existing over it, such as trees, rocks, snow drifts, etc, referred to the lowest outline of the vehicle shape and determined taking into account the most unfavourable conditions shall be at least 1.5 m when the place over which the vehicle passes is not accessible to the public. Where this is not possible, this vertical clearance shall be at least 5 m.
3.2.8 When there are crossings with other communication paths or with overhead electric lines, a minimum clearance shall exist in order to take into account the requirements of 3.7.

3.3 Maximum Speed

3.3.1 The maximum speed shall be determined in such a way that the safety of travel is ensured. The maximum speed, unless otherwise agreed to between the inspecting authority and the ropeway promoter, shall be the following:

   a) For attended cabins: 10 m/s in long spans and 7.5 m/s over trestles.
   b) For unattended vehicles: 6 m/s in long spans and 4 m/s over trestles.

3.3.2 The maximum speed of the vehicle shall also be determined taking into account the braking capacity. The speed shall be such that all the energy contained in the vehicle and the corresponding wire ropes can be transformed into heat without any reduction in the braking effort or any damage to the brake.

3.4 Capacity and Attending of Vehicles

3.4.1 Capacity

3.4.1.1 The calculation of the various element shall be done taking into account the weight of 70 kg per traveller in the case of cabins with maximum capacity of 15 passengers and 65 kg per traveller in the case of cabins with capacity greater than 15 passengers. In the case of ropeways transporting passengers for winter sports or climbing installations, these weights shall be increased by 10 kg per person to take into account supplementary equipment of the passengers.

3.4.1.2 The area at the disposal of the each standing passenger shall be at least 0.22 m² up to 15 passengers and 0.18 m² for each person above 15 passengers.

3.4.2 Attending of Vehicles

3.4.2.1 Each vehicle with capacity of more than 15 passengers shall be accompanied by a conductor. For vehicles of capacity 15 or less, the presence of a conductor is not essential provided the safety of the passengers is not compromised and subject to agreement between the ropeway promoter and the inspecting authority.

3.4.2.2 At a prominent position in the cabin, a nameplate indicating maximum number of passengers and load is displayed.

3.5 Rope Guiding

3.5.1 The permanency of the carrying wire rope on the casing shall be ensured even under the most unfavourable conditions; the height of this trestle being determined as a function of the wire rope load. This load shall be at least 50 percent greater than that, which would be necessary taking into account a gust of wind blowing in the direction of the support reaction equal to 30 kgf/m².

3.5.2 The moving wire ropes shall be protected by guides and such devices that in the case of transverse wind, these wire ropes conserve their normal position in the hollow of the sheaves on which they are resting. In addition, the sheave shape shall be such as to hinder tangling of the wire rope with the trestle or displacement of the wire rope.

3.5.2.1 At a level lower than that of the carriage bottom, a support for the haulage ropes, which might slip off, should be provided on the trestles.

3.5.2.2 Where the moving cable is not supported on a sheave, it shall be generally supported by a roller train whose number depends on the total load exerted by the wire rope at the point under consideration. The permissible load for a roller without a soft material lining shall be 200 kgf and the maximum permissible angle of deflection shall be 2°30'. When the rollers are lined with soft lining, the value of the permissible load may be increased according to the quality of the material (for example, for good quality rubber lining, the maximum load in kgf can reach the value of 4 × wire rope diameter × roller diameter where the diameters are expressed in cm. But in no case, shall the angle of deflection exceed 4°30'. In the case where the wire rope makes an arc of circumference of the sheave, the requirements of 4.7.2 shall also be taken into account. All the rollers shall be mounted on rolling bearings.

3.6 Rescue of Passengers Along the Line

3.6.1 If the aerial ropeway passes over inaccessible terrain or if the height of the vehicles over the ground does not permit rescue of the passengers by direct descent by means of ladders or ropes, a relief cabin operated from a station shall be provided.

3.6.2 In favourable conditions, it is sufficient to provide ladders or equipment, which permit descent by rope. This equipment for descent shall be readily available in the cabin when no other means of safety of passenger is provided.

3.7 Crossings

3.7.1 The crossing of routes, roads, railways, waterways or other ropeways shall be avoided as far as possible. When it is not possible, the clearance shall be determined in such a manner that there is no danger for any vehicle using the various ways enumerated.
3.7.2 The crossings and paralleling with railways, highways, cableways or overhead electric lines shall be so done that no mutual discomfort results either in the course of normal operation or rescue operation or during installation operations. Wherever the local conditions are favourable and the characteristics of the electric lines permit it, the overhead electric lines shall be replaced by underground cables.

3.7.3 Long paralleling with electric overhead lines or contact lines shall be avoided, as far as possible. The distance of separation shall be determined in such a way that the safety of both installations is ensured. Any phenomenon of induction shall not in any way affect. The continuity or integrity of the telephonic or safety systems on either of the installations.

3.8 Dangers

3.8.1 In the proximity of airports or in areas where aeroplanes fly at low altitude or land frequently, the route of the ropeways shall be adequately marked, taking into account any restriction imposed by the authority having jurisdiction over the airports.

3.8.2 The areas exposed to the dangers of natural forces ( avalanches, landslides, rock falls, storms, earthquakes, etc ) shall be avoided as far as possible.

3.8.3 If the dangers indicated in 3.8.2 exist, suitable protective devices shall be provided.

3.9 Wind Action

3.9.1 Under normal conditions, it is necessary to take into account the wind action considering the following values of pressure:

   a) Installation not in service (vehicles protected from wind):
      \[ P = 120 \text{ kgf/m}^2 \]
   b) Installation in service:
      \[ P = 30 \text{ kgf/m}^2 \] (for effect due to inclination, see 3.2.5)

3.9.2 In areas subjected to storms and where the wind velocity frequently exceeds 150 km/h, the maximum value ascertained in the area under consideration shall be taken into account for calculation purposes.

3.9.3 In the calculation of the wind action on the wire rope, the surface area to be considered shall be the diametral surface of the cable multiplied by the factor \( C_w = 1.1 \). For calculating the wind action on the vehicles, the following factors shall be used:

   Suspended carriages, \( C_w = 1.6 \)
   Cabins, \( C_w = 1.0 \)

4 WIRE ROPE

4.1 General

4.1.1 As far as possible, all wire ropes shall be in single piece and shall be of non-rotating construction. Welded joints in the rope shall be spaced at least 6 times the pitch of the wire and their number in 500 m length shall not exceed the number of wires in the wire rope.

4.1.2 Before the wire ropes are put into service, they shall be checked by a suitable non-destructive method, like magneto-inductive test, to ensure that no rope with broken wires is put into service.

4.1.3 The lubricants incorporated in the wire rope during manufacture and use shall not exert any corrosive action on the material of the rope. The lubrication of the rope during service shall be done in conformity with good established practice and according to the specific requirements.

4.1.4 Care shall be taken to avoid any twisting or kinking of the rope while unreeling the rope or in service.

4.2 Carrying Wire Ropes

4.2.1 Locked coil ropes of full locked or half-locked construction, sheave wire ropes as well as stranded wire ropes may be used. Completely round wire ropes with round wires are not permitted. The core shall be a stranded wire or independent wire rope.

4.2.2 The nominal breaking strength of the wire rope at the time of putting into service shall not be less than 3.3 times the maximum axial load met with in service calculated for the most unfavourable conditions or circumstances.

4.2.3 When the effort due to breaking of the vehicle does not exceed 15 percent of the maximum tension, this load may be neglected. For calculation purposes, the coefficient of friction between the wire ropes and the shoe in bronze or similar material can be taken equal to 0.10 for locked coil ropes and 0.15 for stranded wire ropes. For steel shoes, these coefficients shall be increased by 20 percent. For calculating the normal load to which the carrying wire ropes are subjected, the load on the rollers defined in 4.7.1, which limits the amount of bending, shall be taken into account in addition to the requirements of 4.3.2.

4.3 Haulage and Ballast Wire Ropes

4.3.1 Stranded wire ropes with metallic or fibre core are suitable.

4.3.2 The nominal breaking strength of the haulage or the ballast wire rope shall be at least 4.5 times the maximum tensile load met with in service. In the
calculation of the maximum tensile load the most
unfavorable combination of circumstances shall be
taken into account. Loads due to atmospheric influence
and due to wind may be neglected.

4.4 Tensioning or Regulating Ropes

4.4.1 The tensioning or regulating ropes shall be of
the ordinary lay type with a single layer of strands or
have full locked coil type. Ropes of the Lang's lay
type may be used only if the rotation of either the
counter-weights or the coupling to the carrying traction
rope is prevented.

4.4.2 The nominal breaking strength of the tensioning
or regulating ropes shall be at least 5.5 times the
maximum axial load in the rope during operation.

4.5 Telephonic and Signal Wire Ropes

4.5.1 The telephonic and signal wire ropes shall be
of the stranded type and protected against corrosion.
Wire rope of any other construction is permissible
provided the safety of operation is ensured.

4.5.2 The nominal breaking strength of the wire ropes
shall be not less than 3.3 times the maximum axial load
met within service.

4.6 Auxiliary Wire Ropes (Auxiliary Cabin Wire
Ropes)

4.6.1 The auxiliary wire ropes are generally stranded
wire ropes.

4.6.2 The nominal breaking strength of the rope shall
be not less than 3.3 times the maximum tensile load
met with in service.

4.7 Loads on Sheave

4.7.1 Normal Load

4.7.1.1 The number of rollers shall be such that the
maximum load on any one of them does not exceed
one-eighth of the minimum tension for the carrying
cable at the point considered. It is recommended that
a ratio between the normal load in the cable produced
by the vehicle and the minimum tension of the carrying
cable not exceeding one-twelfth is adopted.

4.7.1.2 For normal loads in moving wire ropes, the
requirements of 3.5.2.2 shall be taken into account.

4.7.2 Sheaves, Drums and Shoe

The fixed drums to which the carrying ropes are secured
by friction shall have a diameter of not less than
65 times that of the wire rope and 1 000 times that of
the outer wires of the wire ropes. The wire rope should
at least make three rounds of the drum and it should
be served at least by two fasteners at the outlet, of
which one assures the proper fixation and the second
serves to check the slip of the wire rope, if any, and
functions as the safety device.

4.7.2.1 The diameter of the pulleys which tensions
the carrying ropes fixed directly to the counter weights
shall be at least 100 times that of the wire rope.

4.7.2.2 The radius of the roller and returns for
tensioning the wire ropes fixed directly to the counter
weights shall be not less than 100 times that of the
wire ropes and 1 200 times that of the wires of the
wire ropes.

4.7.2.3 The diameter of deviation pulleys of stranded
stretch wire rope shall be not less than 40 times that
of the wire rope and at least 600 time that of the wire
in the outer layer of the wire rope. These pulleys shall
be provided with linings in leather, wood or any other
relatively soft material.

4.7.2.4 The diameter of the driving and return
sheaves shall be not less than 80 time that of the
hauling rope and at least 800 time that of the wires of
the wire rope.

4.7.2.5 The support saddles with support the carrying
rope shall present such a profile that while passing
the trestles, any danger or displacement of vehicle is
avoided. They have to ensure the equilibrium tension
in the wire rope and to permit free displacement of
the wire rope in the longitudinal direction when
necessary, by making use of the rollers. The radius
of curvature of saddle supports shall be at least 300
times that of the wire rope diameter.

4.7.2.6 The radius of curvature of the saddle supports
shall be adapted to the speed at the passing of the
trestles. To this end, the following requirements shall
be satisfied:

\[
\frac{V_s^2}{R} = 2 \text{ m/s}^2
\]

where

\[ V_s = \text{the speed over the trestles, in m/s; and} \]
\[ R = \text{the radius of curvature of saddle support,} \]
\[ \text{in metres.} \]

Where necessary, the normal speed shall be reduced
to bring the value to the permissible value while passing
over the trestles.

4.8 Splices and Rope Termination

4.8.1 Experienced personnel shall make all splices.
The length of a splice shall not be less than 1 300 times
the rope diameter. The distance between two
contiguous splices shall not be less than 3 600 times
the diameter of the rope. However, two additional
splicing may be permitted in case of repair after an
accident.
4.8.2 Rope socketing shall be done with the utmost care. Only organizations which can prove their experience as regards the proper making of rope sockets shall be entrusted with this operation unless the ropeways promoter himself has well-trained personnel for carrying out this operation.

4.9 Testing and Acceptance of Ropes
4.9.1 The ropes shall conform to the relevant Indian Standards.

4.10 Replacement of Ropes
Generally a rope should be withdrawn from service when it is considered that:

a) The loss of strength in the rope due to wear or corrosion or both is approaching one-sixth of the original strength;
b) The loss of strength in the rope due to fatigue, surface embrittlement or cracked and broken wires of any kind is approaching one-tenth of the original strength;
c) The outer wires have lost about one-third of their depth as result of any kind of deterioration;
d) The outer wires are becoming loose and displaced for any reason;
e) The rope has become kinked, distorted or damaged and the damaged piece cannot be removed; and
f) Examination of the rope leaves any doubt as to its safety for any reason whatsoever.

5 STATIONS
5.1 General
5.1.1 According to the climate of the area where the ropeways are situated, suitable shelters for passengers and personnel shall be provided. In every case, stations shall be provided with water-closet.

5.1.2 The station machinery such as mechanical parts of the driving gear, electrical equipment, ropes and vehicles shall not be a source of danger to the passengers and ropeways personnel. The passenger's entrance shall not cross the path of the travel of the vehicle.

5.1.3 The whole of the driving gear and of the return or deflection devices shall be protected against bad weather. In addition, care shall be taken to prevent the entrance to the machine room of unauthorized persons to avoid any possible accident to them.

5.1.4 The ropeway operator shall be located, where he shall have the best possible view of the route. The controls and communicating devices shall be within the reach without his having to leave his position.

5.1.4.1 The control panel shall be provided with the following:
   a) Speed indicator,
   b) Indicator for the vehicle position, and
   c) Fault indicator.

5.1.4.2 A speed control device which automatically stops the vehicle when the speed of vehicle approaching the station has not been suitably reduced, shall be provided.

5.1.5 Fire hazard shall be reduced as far as possible. A sufficient number of extinguishers guaranteed to function effectively shall be kept ready in case of need and installed in places which are readily accessible.

5.2 Driving and Braking
5.2.1 The driving gear shall be provided with an emergency motor fed by auxiliary power which can ensure reduced operation as needed even when there is something wrong with the main motor or even in case of power failure.

5.2.2 The speed of the system shall be maintained constant irrespective of any load conditions. To this end, the speed shall be regulated to +4 percent, whatever is the load.

5.2.2.1 The main driver shall also regulate the speed of the system in such a way as to ensure at lower speed while entering the station and when necessary over the trestles as well as during the periodical arrivals of the wire rope. In the last case, the speed shall be within 0.3 and 0.5 m/s.

5.2.2.2 Starting under the most unfavourable conditions of load shall be guaranteed whatever be the type of driver used.

5.2.2.3 When the motor is not in action or when there is a power failure, the transportation of passengers is forbidden.

5.2.2.4 In the case of downward load, the driver itself shall exert a continuous braking action.

5.2.3 Travel with the main motor shall be stopped automatically when any brake is on or if any safety device operates.

5.2.4 Rope Adhesion on the Driving Sheave
5.2.4.1 The friction coefficient (µ) between the rope
and the surface of the groove of the driving sheave are as follows:

a) Groove without lining (cast iron or steel) \( \mu = 0.07 \)

b) Groove with leather lining \( \mu = 0.15 \)

c) Groove with rubber or similar material with high friction coefficient \( \mu = 0.25 \)

d) Groove with special material lining \( \mu \) to be agreed between the ropeways promoter and the inspecting authority.

5.2.4.2 The contact angle of the rope on the driving sheave shall be such as to ensure that in the most unfavourable combination of circumstances the required power is transmitted to the rope.

5.2.5 As far as possible, chains or belts shall be not used for power transmission. However, in the case of small powers, the use of V-belts is permitted provided at least 4 are used for transmitting the power.

5.2.6 Two different friction brakes shall be used to cause both normal stopping and the emergency stopping. One of these brakes is called service brake and the other emergency brake. Each of such brakes shall be able to ensure the stopping of the installation motion even under the most unfavourable conditions of loading on the average nominal deceleration of 0.5 m/s².

5.2.6.1 To avoid sudden breaking with all the consequent and undesirable oscillation of vehicles, it is recommended that the braking action be automatically proportioned to the load conditions of the lining and is applied in a gradual manner.

5.2.6.2 The emergency brake shall act directly on the driving sheave and its braking effort shall be induced by a counter weight or springs and its operation shall be carried out in such a manner that its regular work can be automatically and constantly checked. It shall also be capable of manual operation. This brake shall act automatically when the speed of the halting cable exceeds the permitted value by more than 15 percent.

5.2.6.3 The service brake besides ensuring the bolding the driving gear when the installation is stopped shall work when the electric power fails or when the value of the absorbed load is too high. Moreover, it shall also work automatically when the remote control installed in the station is in action or when any safety device is operated (see 5.2.2.3).

5.2.6.4 The safety factor of all parts forming the brakes shall not be less than 5.

5.3 Rope Tensioning and Anchorage Devices

5.3.1 The spaces in which the counterweights travel (in pit or construction above the ground) shall be protected from water, snow, and ice and from any other material. It shall be ensured that the above elements do not accumulate inside these spaces. These spaces shall be provided with guard-rails in order to prevent the entrance of unauthorized persons.

5.3.2 The mobility of the counterweights shall be ensured at all times.

5.3.3 The travel of the counterweight shall be determined taking into account the maximum variation which may be due to the sag of each span, the surrounding temperature of the zone where the installation lies (minimum variation to be considered is 60°) and the elastic stretch of the rope.

5.3.4 Where several tensioning ropes are laid in parallel, all the necessary precautions shall be taken in order to ensure uniform distribution of the tension among such ropes.

5.3.5 In place of tension ropes, chains can be used provided they are proved to be sufficiently safe. The safety factor shall be at least 7 in this case. Other systems are permissible subject to agreement between the ropeway promoter and the inspecting authority.

5.3.6 The foundations of either tensioning devices or those of the anchorage shall have a safety factor of 1.5 in respect of shifting and over turning. Such safety factor is to be calculated on the basis of a conventional assumption that these foundations are free, that is, there is no lateral movement of the earth.

5.4 Other Requirements

5.4.1 In stations, the vehicles shall be guided in such a manner that at the entrance or exit of passengers no lateral unbalancing is produced.

5.4.2 In terminal stations, current interrupters shall be provided at the end of the vehicle train.

5.4.3 Equipment meant for maneuvering of wire ropes and other mechanical and electrical equipment shall be provided in stations.

5.4.4 For supplying of vehicles and for vehicle replacement sufficient garage space shall be provided.

5.4.5 The platforms shall be provided with parapets wherever it is necessary to avoid accidents to persons.

5.4.6 Rope pulleys shall be manufactured from high quality cast iron, malleable cast iron or steel and shall be mounted on roller bearings.

6 TRESTLES

6.1 Loads

In designing trestles, the following stress values shall
be taken into account:

a) The weight of the trestle and the pressure exerted by the ropes; and

b) The whole of the stresses due to friction met with during the motion of the moving ropes and during the displacement of a stationary rope.

6.1.1 In order to determine the friction loads with separate margin of safety, the following values shall be taken into account:

a) For carrying cable on shoes — A friction coefficient of 0.13 for low cable ropes and 0.18 for stranded wire ropes,

b) For haulage ropes — A coefficient of 0.025,

c) Vehicle load under the oscillation of maximum static load, and

d) Wind load or snow load.

6.1.2 The wind load due to wind action shall, as far as possible, take into account the special local characteristics of each installation ( zones exposed to storms ). Also it will be useful to take into account the requirement of wind direction on similar equipment like trestles, towers, hoists, etc.

6.2 Safety

6.2.1 The metal parts of the trestle shall have a safety factor, defined as the ratio of the strength of the metal to the stress under the most unfavourable conditions, of not less than 3 when the installation is in service and 2.2 when the installation is not in operation.

6.2.2 Under the most unfavourable conditions of loading, whether in service or not, the trestles shall have a minimum safety factor of at least 1.5 times to overturning displacement or subsidence. Such calculations shall take into account the lateral movement of the earth except in the case of contact terrain.

6.2.3 The elastic deformation of the trestles, in particular those due to torsion which happens during normal conditions of operation, shall not be such as to endanger the safety of the guides and the stability of the ropes. The maximum angle of deformation due to torsion shall be limited in such a manner that the ends of the shoes for supporting the carrying-hauling rope are not displaced by more than 20 percent of the wire rope diameter.

6.3 Construction

6.3.1 The number of trestles, their position, their height and their construction are determined by the requirements of the route and the layout. Wooden trestles or trestles which are guyed, shall not be used.

6.3.2 In case the trestles have metallic framework, the thickness of the open profile shape shall not be less than 5 mm while in the case of closed profile; it shall not be less than 2.5 mm. The interior of the latter shall be adequately protected against corrosion.

6.3.3 The anchorage of the trestles on the concrete foundations or on the rock shall be carefully made. The anchor bolts of concrete foundations shall just be above the ground.

7 VEHICLES

7.1 Safety Factor

For all components constituting the vehicles, the safety factor shall be at least 5 under both static and dynamic conditions.

7.2 Construction

7.2.1 The vehicle shall be suspended in such a manner that whatever be the slope of the track, the cabin remains suspended in the vertical position.

7.2.2 The vehicle shall be so designed that even when it is empty and under the wind pressure for which it is designed, the transversal inclination of the vehicle with reference to the vertical does not exceed 20 percent.

7.2.3 The glass used in the vehicle shall be safety glass.

7.2.4 Suitable devices shall be provided to automatically close the exit doors when the vehicle is in motion.

7.2.5 The weight of the vehicle shall, as far as possible, be equally distributed on all the rollers. The roller shall be lined with soft material and mounted on bearings.

7.2.6 The vehicle shall carry a retaining device, which shall, as far as possible, take support on the carrying wire rope in the case of the falling down of the vehicle.

7.3 Brakes

7.3.1 The vehicle shall be provided with an automatic carriage brake, which acts on the carrying rope or on a static rope called the brake rope in the case of braking of a haulage or ballast rope. This brake shall be capable of manual operation by the operator also. It should also be capable of being disengaged by the operator after it has functioned.

7.3.2 The braking effort shall be such that the value of deceleration produced is sufficient in all casts even under the most unfavourable conditions of loads and slope to ensure braking within a reasonable distance.
7.3.3 The braking shall be such that even when the conditions of the brake are favourable to jolting of the vehicles under no load, the brake provided shall be such as to avoid any pronounced jolts.

7.4 Equipment

Each vehicle shall be provided with relief lights.

8 COMMUNICATION, SAFETY CIRCUITS AND EARTHING OF METALLIC PARTS

8.1 Communications

8.1.1 The stations shall be linked to each other by telephone. At least one of the stations shall be linked up with the public network, wherever the latter exists.

8.1.2 Communication facilities (telephone or wireless) shall be provided in the vehicle for communication with the driving station or with the second vehicle. Other safety devices shall be provided for help in case of the failure of the telephone.

8.2 Safety Circuit

8.2.1 All the safety devices along the length of line and in the stations shall be incorporated in the continuous circuit energized permanently so that when any one device fails or the signal line fails, the system automatically comes to a halt.

8.2.2 The haulage ropes and the ballast ropes shall be isolated from the earth so that in case of brake or derailment, the short circuit produced if these come in contact with earthen members automatically brings the vehicle to stop and brakes the installation.

8.3 Earthing

8.3.1 All the metallic portions of the installation with an exception of auxiliary ropes, signal ropes, ballast and haulage ropes shall be directly earthed.

8.3.2 The entire ropeways system shall be provided with suitable protection against lightning.

ANNEX A

(Foreword)

INDIAN STANDARDS ON WIRE ROPES AND WIRE PRODUCTS

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<tr>
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<tr>
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<td>Glossary of terms relating to wire ropes (first revision)</td>
<td>3937</td>
<td>Recommendations for socketing of wire ropes:</td>
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<td>(Part 1): 1974 Socketing with zinc (first revision)</td>
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<td>(Part 2): 1974 Socketing with white metal (first revision)</td>
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<td></td>
<td>(Part 3): 1994 Socketing with resins (first revision)</td>
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<td>1855:1977</td>
<td>Stranded wire ropes for winding and man riding haulages in mines (first revision)</td>
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Amendments Issued Since Publication

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