CODE OF PRACTICE FOR DESIGN, MANUFACTURE, INSTALLATION, OPERATION & MAINTENANCE OF FUNICULAR RAILWAYS

機電工程署
EMSD

Code of Practice for Design, Manufacture, Installation, Operation & Maintenance of Funicular Railways

Electrical and Mechanical Services Department
The Government of Hong Kong Special Administration Region
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EMSD

Contents

Part 1 Foreword

1.1 This Code of Practice was issued by the Electrical and Mechanical Services Department (abbreviated as "EMSD") of the Government of the Hong Kong Special Administrative Region. It is the intention of this Code to advise on the fundamental areas for consideration when the design, manufacture, installation, operation and maintenance of a funicular railway are being planned.

For the compilation of this document reference has been made to the Swiss Funicular Railway Ordinance.

Construction of a funicular railway together with associated buildings shall comply with the provisions of the Buildings Ordinance (Cap. 123) and the Construction Sites (Safety) Regulations (Cap. 39 Sub. Leg.)

The electrical work shall comply with the following:-

(i) Electricity Ordinance, Cap. 406.

(ii) The latest edition of BS7671: Requirements for Electrical Installation. IEE Wiring Regulations, or any other equivalent international standards.

(iii) The "Supply Rules" issued by either Hongkong Electric Company Limited or CLP Power Hong Kong Limited as appropriate.

In addition, reference must be made to other Laws of Hong Kong and British Standards Specifications where applicable. These are referred to in the text and may be seen in the list of references at the Appendix.

1.2 It is not the intention of this Code of Practice to prohibit the inclusion of innovation and improvement in design and performance but it must be stressed that any such developments should be fully supported by sound engineering principles.

Enquiry on any subject can be made to the Director of Electrical and Mechanical Services unless otherwise stated. (Hereinafter referred to as "the Director").

Section A Design, Manufacture and Installation

Part 2 Scope

2.1 Definition

"Funicular Railway" means any engineering system for the transport of passengers or goods on slope in carriers or vehicles running along rails at ground level and drawn by a rope at one end, together with any machinery, equipment or plant connected therewith. (N.B. this Code of Practice will not deal with aerial ropeways or inclined lifts which are governed by other relevant Ordinances).

2.2 Limitations

This Section of the Code of Practice is intended to give guidelines on the design, manufacture and installation of funicular railways but nothing herein contained shall replace the provisions of any standard in force in the Hong Kong. The Director will make revision to this section from time to time to suit the technological development in the field of funicular railways.

2.3 Planning

When planning the location and route of a funicular railway the following factors must be carefully considered.

(a) Amenity Value

Any passenger-carrying funicular railway intended for use by the general public shall be so located that adequate facilities for inter-connecting public transport are available at the terminals.

(b) Route

A funicular railway shall be routed so that its effect on the environment is minimal; this involves consideration of noise pollution, unsightly construction and any detrimental visual impact on the local environment. In the design of the routing of a funicular railway, due regard shall be given to existing hazards such as vegetation, roads, bridges, electric power lines, streams, buildings and slope stability. An environmental impact assessment shall be carried out to address this subject in accordance with any other legislative requirement in force in Hong Kong.

A geotechnical assessment of the proposed route should be carried out, based on which a site investigation programme should be designed and implemented. The design of foundations for the rail and roller shall be in accordance with the requirements of the Geotechnical Manual for Slopes and shall be submitted for approval to the appropriate Government Office/Department as required by statute or any project design brief.

Adequate consultation on various details of the project shall be conducted with relevant organizations and the local community. If land resumption is a related issue on the project, all necessary procedures as required by any other legislative requirement in force in Hong Kong shall be followed.

(c) Emergency Access

Adequate access to terminal stations by emergency vehicles as may be required by the Fire Services Department (abbreviated to "FSD") shall be provided. A rescue plan shall also be drawn up in consultation with FSD and EMSD to deal with emergencies during operation.

(d) Submission of Plans

Any company or organization wishing to install a funicular railway shall submit to the Director the design, specifications, plans and calculations relating to the railway, together with such other information as may be required by the Director.

Part 3 General Design

3.1 Every part of a funicular railway installation and its associated equipment shall be designed with consideration given to the safety of the passengers, the general public and operating staff, and shall be designed in compliance with this Code of Practice.

3.2 Because of the high probability of any structure in Hong Kong being subject to the effect of severe winds and very heavy rainfall, the design of any exposed equipment and the selection of any materials used in the construction of a funicular railway shall give due regard to these factors. Wind may act in any direction, including upward direction. As a general rule the pressure of the wind P_w N/m^2 on funicular railway and all exposed equipment may be calculated by the following empirical formula:-

$$P_w = V_w^2/1.6 \quad N/m^2$$

where V_w is the maximum expected wind velocity in m/s in the vicinity of the line.

The above empirical formula may be adjusted proportionately by any variation in temperature or density of the air from the nominal condition of 15^oC and 1.25 kg/m^3. However, even without any adjustment, this value is considered appropriate as a first approximation. The vehicle shall be designed to sustain a minimum wind load of 250 N/m^2 in operation.

3.3 The earthquake loading shall be assumed to be equivalent to a ground horizontal force of 0.08 times the total weight of the building, structure or rail.

3.4 Prior to the construction of a funicular railway the manufacturer shall furnish a full set of engineering drawings, together with the design calculations to the Director. During construction and testing, submission of test certificates, reports from the manufacturers and the commissioning team shall also be required.

3.5 In addition to Section 3.4, a general layout and an extract from the Survey and Mapping Office map to a scale of 1:1,000 showing the line and plan (to scale) and any topographical features is required. Accompanying this, a written description indicating the size and capacity of the installation, the operational philosophy together with an assessment of the likely usage is required to assist in determining if inter-connecting public transport will need to be arranged.

3.6 It is necessary to ensure that on a funicular railway the rope will be required to keep its normal position by the rope guidance devices and supports under any condition of operational speed or load and, in addition, under the influence of any external factor such as wind effects.

3.7 The sheave guides etc., shall be designed to accommodate any side thrusts, if applicable.

Part 4 Strength of Material

4.1 Standards for material strength such as yield stress, tensile strength, safety factor for general applications, etc. shall be determined in accordance with the recommendation of established national/international standards or codes for funicular railway systems or similar applications.

Part 5 Travelling Speed

5.1 The operating speed of a system shall be designed having regard to:-

(i) the safe and steady operation of the vehicle;

(ii) the operational capability of the braking systems;

(iii) the condition of the track;

(iv) static and dynamic forces on the vehicle; and

(v) comfort of the ride.

5.2 Normally, operating speeds of up to 3.5m/s are permitted. However, in view of technological advancement, operating speeds of up to 10m/s are permitted, provided that:-

(i) all effects of the higher speed have been taken into account;

(ii) the track is not accessible to the general public;

(iii) the operating speed is continuously adjustable over the whole length of travel;

(iv) the whole track, except for cross-over, is straight or the radius of any curve (in m) is at least 6 x V^2 where V is the operating speed in m/s; and

(v) the vehicle is equipped with suitable type of suspension.

5.3 The maximum operating speed may be exceeded under test conditions, without passengers, for the purpose of inspecting the overspeed safety devices. The test shall be carried out by competent and responsible staff and under no circumstances the carrying out of the test should prejudice safety.

5.4 For operating speed exceeding 6m/s, the haulage rope shall be guided and guarded properly and prevented from coming into contact with adjacent surfaces/objects.

5.5 When the vehicle is powered by emergency supply, the operating speed shall be suitably reduced to prevent overloading the emergency supply system. The emergency supply must be, however, able to drive the vehicles to reach either terminal station from any location within one hour.

Emergency supply system could be an emergency generator or a standby supply from the power company.

Part 6 Rollers, Sheaves and Drums

6.1 The diameter of lined sheaves and drums for haulage rope shall be at least as follows (measured in terms of nominal rope diameters):-

Diameter of	As multiples of rope diameter	As multiples of outer wire diameter
Sheaves, haulage drum	80	800
Fastening drum	22	---

For unlined sheaves and drums, the values given above shall be increased by at least 25%.

6.2 The maximum allowable deflection shall be 10% for lined rollers, and 7.5% for unlined rollers.

6.3 The distance between successive rollers shall be designed such that even when it oscillates, the haulage rope shall not come into contact with the sleepers on the track.

Part 7 Rope Requirements

7.1 Before the commencement of operation, and to provide a datum for comparison with the inspection of ropes during operation, it is recommended that the new ropes shall be examined by means of an electromagnetic testing instrument (defectograph), or by any other non-destructive testing system which can locate defects in the wires.

7.2 Lubricant shall be supplied to the wires at the manufacturing stage and any fibre core shall be similarly impregnated. In operation, the rope shall be lubricated at recommended intervals. In both cases, the lubricants (preferably the same) shall be compatible with each other as well as having no corrosive action on any part of haulage system with which it may have contact, especially rubber liners on sheave and drive wheels.

7.3 The ropes are generally of the steel wire stranded type. A safety factor of 8 must be used with respect to the maximum axial load of the rope compared to the calculated breaking load; but in such a case allowance for the line friction (resistance of the line rollers) shall be taken into account when determining the maximum axial load. (see Section 10.8)

7.4 For telephone and signalling cables the safety factor shall be at least 3.3 times the maximum designed axial stress. Cables used for telephone and signalling purposes shall not come into contact with the haulage ropes under the worst possible operating conditions.

7.5 <u>Testing and Certification of Ropes</u>

7.5.1 The testing and acceptance (or rejection) of ropes shall be fully documented in accordance with British Standard BS 302: Part 5: 1987 or other equivalent international standards. The British Standard may not cover specifically stranded ropes for funicular railways, but the procedures laid out therein are considered suitable for this application and shall be adopted.

7.5.2 After the testing and acceptance of a rope the purchaser shall obtain a certificate from the manufacturer as to the detailed specifications of the rope and the constituent wires with regard to their strength, size and dimensional stability. In addition, the Director may require independent inspection.

Part 8 Splicing and Rope Terminations

8.1 Splicing of the haulage rope is not permitted.

8.2 The haulage rope fastening to the vehicle shall be easily accessible for inspection and adjustment.

8.3 Reel-type fastening to vehicle shall have a safety factor of 4 as measured against the greatest traction force in the rope. Other types of fastening shall be designed for the breaking load of the rope.

8.4 The fixing of the ropes onto the haulage drum shall be carried out using a system of blocking with wedges, or using at least two clamps or any other system of equivalent design from the safety point of view. These attachments shall be easily accessible for inspection and tightening. If the size of the drum permits, the rope shall first pass through a hole in the drum barrel or flange and be secured on the inside of the barrel or on the outside of the flange. The termination shall be able to resist at least 80% of the breaking load of the rope.

8.5 If end sockets are to be used, they must be fitted with care. For this purpose only firms who specialize in this technique and can prove their experience, both as regards the making of the sockets and the choice of correct materials, shall be employed, unless the funicular railway company has its own qualified personnel who have proper experience in this work. During service the rope ends shall be easily accessible for inspection.

8.6 The sockets shall be fitted with a white metal that may be applied at a temperature below that of any critical temperature which will alter the metallurgical or mechanical properties of the wire.

8.7 The wires in the cap shall be spread to evenly distribute the load and arranged that no bending moment is applied to the rope as it leaves the socket.

8.8 On installation of an end socket a transverse reference mark shall be made so that any displacement can be readily detected visually.

8.9 The end socket shall have a strength at least that of the parent rope. It shall be protected from the ingress of water or any other substance that may be corrosive or affect the integrity of the fixing.

Part 9 Rope Replacement

9.1 A rope on a funicular railway shall be replaced in the event of wear, corrosion, broken or damaged wires. The followings are situations requiring rope replacement:-

(a) there is a reduction of 25% in effective bearing cross sectional area within a rope length equal to 40 times rope diameter;

(b) if within a rope length equal to twice of the rope diameter, more than half of the crown wires (or an equivalent cross section) in one and the same strand are broken; or

(c) the condition of the rope or its performance leaves any doubt as to its integrity and safety in operation.

9.2 For the purpose of calculation of reduction in effective bearing cross sectional area in Section 9.1, the followings are relevant -

(a) if the reduction of cross sectional area is the result of broken wires, the sum of the cross sectional areas of all the broken wires within the relevant length shall constitute the total amount of reduction;

(b) if there are several breaks in one and the same wire within the relevant length, only one wire's cross sectional area has to be taken into account; and

(c) loose wires and wires having strand deformation shall be considered as broken.

Part 10 Drive

10.1 The main drive shall be able to operate under any loading condition from rest to any selected speed within the design range. As far as practicable the speed selected shall be suitably controlled and be constant with variation limited to ±5% of the selected value.

10.2 The maximum designed speed shall be governed to produce an indication at +5% with power trip off at +10%. Lower values may be used if desired.

10.3 The starting of the motor shall be smooth and without jerking regardless of the load. Starting acceleration shall be adjusted according to the track characteristics, and passenger comfort considerations.

10.4 For funicular railways with travelling speed exceeding 4 m/s, the speed control shall be continuously variable.

10.5 Flat belts and chains shall not be used for the main drive.

10.6 It shall be possible for the motor to drive the rope at 0.3m/s or at such a speed so as to allow the entire length of the rope to be inspected.

10.7 For the purpose of calculating the necessary drive output of the motor and the rope tension, the weight of a person shall be taken as 75 kg.

10.8 The running resistance of lined rollers shall be taken as at least 3%, and of unlined rollers as at least 1% of the load exerted on each roller when the rollers are provided with anti-friction bearings.

10.9 The resistance of rope sheaves shall be taken into account in calculating the necessary drive output.

Part 11 Brakes

11.1 When the vehicle is to stop in a normal manner, the deceleration shall be achieved by means of an electrical brake at, as far as practicable, a constant deceleration sufficient to slow down the vehicle. In this respect, a deceleration value of at least 0.2m/s^2 shall be achieved. The deceleration shall be monitored by the deceleration monitoring circuit.

11.2 The main drive shall be provided with a service brake and an emergency brake, each capable of independently stopping the vehicle. Both brakes shall be operable in both directions of travel. Normally the two brakes shall not come into operation simultaneously.

11.3 The service brake, with deceleration control, shall be set to achieve a retardation of 0.6m/s^2. After normal stopping of the vehicle, the full braking power of the service brake shall be brought into action. When the vehicle stops, the power supply to the driving motor shall be turned off. If self retardation due to gravity exceeds 0.6m/s^2 then the brake shall remain ineffective until the system stops and then they shall act at full power. The emergency brake, without deceleration control, shall be set to achieve a retardation of at least 0.6m/s^2 in the most adverse line conditions for full downhill load/empty uphill load and a maximum of 1.5m/s^2 in the most adverse line conditions for full uphill load/empty downhill load. In all cases, the emergency brake, when applied at any point during the normal deceleration phase during entry to station, must be capable of stopping the vehicles before the buffers at the terminal stations, irrespective of the load.

11.4 With an electrical main drive motor, the service brake shall operate automatically as soon as:

(a) The speed controller is brought into neutral position, if speed controller is installed;

(b) The electrical braking is almost completed;

(c) The supply power is lost, interrupted or the voltage falls below a permissible level, or in the case of three-phase circuits, the supply fails in any one phase;

(d) The power demand rises above a permissible level;

(e) The maximum permissible running speed is exceeded by 10%; or

(f) Any of the safety devices listed in Part 12 operates.

11.5 The service brake shall be designed that it can be operated from the vehicle. If necessary, the operation of the service brake shall be load-dependent. The braking power of the service brake during normal braking shall be controlled as to develop a deceleration from 0.3m/s^2 to the maximum value stated in Section 11.3.

11.6 The service brake and emergency brake must operate directly upon the driving wheel or a brake rim attached thereto. The braking force shall be applied in two positions on the wheel or the rim diametrically opposite. For funicular railways with a travelling speed of less than 3m/s, one of the brakes may operate on the transmission gear, on condition that adequate heat dissipation arrangement is to be provided.

11.7 For funicular railways with travelling speed exceeding 3 m/s the speed sensor for the emergency brake and its automatic application shall be effected directly from the driving wheel.

11.8 The emergency brake shall be able to be brought into action by hand at the control console either mechanically or electrically. Emergency stop switch or push button to stop the vehicle shall be provided at the following locations:-

(a) control console in the control room;

(b) on the platforms;

(c) control panel in the vehicle;

(d) in the machine room; and

(e) in the passenger compartments if the vehicle is not attended.

(f) in the vehicle inspection pit.

For items (b), (e) or (f), either the emergency brake, or the service brake, should be applied to stop the vehicle

11.9 The emergency brake shall come into operation automatically under the following conditions:-

(a) when the maximum permissible running speed is exceeded by 15-20%;

(b) when the vehicle overshoots its normal stopping position at the driving station;

(c) when the service brake fails; or

(d) when the pressure in the hydraulic or pneumatic circuit for holding open the brake drops below the specified level.

11.10 In the event of overspeed, the emergency brake shall operate automatically in both directions of travel and shall be fail-safe, i.e. not dependent upon the power derived from mains supply or batteries. The braking force of the emergency brake~~s~~ shall be produced by weights or compression spring. The overspeed governor shall have an accuracy of ±5%. Automatic resetting of governor shall not be allowed.

11.11 When the emergency brake is applied, the electrical supply to the drive motor shall be tripped-off. When the emergency brake is controlled (held open) hydraulically or pneumatically, the hydraulic or air pressure shall be completely released immediately. To avoid excessive deceleration, the operation of the emergency brake may be delayed.

11.12 The braking force of all brakes shall be easily adjustable. When the brakes are held open hydraulically or pneumatically, the corresponding pressure shall be capable of being monitored.

11.13 The components of the brakes shall be designed with a minimum factor of safety of 3.5 as measured against the tensile yield strength.

11.14 Due consideration shall be given to the temperature rises when calculating the dimensions and efficiency of the brakes.

Part 12 Safety Devices and Control Circuit

12.1 The control room shall be located in the driving terminal and shall be so orientated as to afford the best possible view of the line. The approaching of vehicle and the boarding and alighting of passengers shall be clearly visible in front of the control console inside the control room. However, the use of CCTV will be accepted as an alternative.

12.2 All control and safety circuits/devices shall be monitored and annunciated by means of indicator lights or audible alarms. All instruments and devices required for monitoring of the operation shall be housed and made easily accessible in the control room.

12.3 All instruments and lamps shall be clearly labelled, as to their functions, in both English and Chinese. Signal lamps shall be clearly visible when lit. When necessary, the signal lamp can be accompanied by audible signal.

12.4 To safeguard the failure of the control system at the vehicles, a manual control system shall be provided at the control room which makes it possible to run the vehicle at a maximum speed of 2m/s.

12.5 Starting up of the vehicle shall only be possible when:-

(a) the corresponding start command has been initiated from both vehicles;

(b) "Door Closed" signal(s) from both vehicles; or

(c) the corresponding "Start" command from the control console at the control room.

12.6 Any intended reversal of the direction of travel shall be possible only after the vehicles are brought to a complete standstill/stop.

12.7 Vehicle position indicator to show the vehicle position in meter and with the indication derived from the signal of a counting device at a deflection sheave of the haulage rope or main haulage drum (in case of winch drive) shall be provided. The position of all stations and crossing points shall also be shown. When two vehicle position indicators are provided at different locations, their indication shall be synchronized. The vehicle position indicator shall be capable of automatically corrected so that it is set to the starting positions when the vehicles are in the termini.

12.8 In particular, the followings shall be monitored with indication displayed at the control room:-

(a) the status of drive, i.e. by main drive or auxiliary drive. Interlocks shall be provided that both drives shall not operate simultaneously;

(b) the position of the brakes;

(c) the condition of wear of the brake shoes.

12.9 The funicular railway shall be provided with end switches and buffers. The end switches shall bring about automatic stopping and impose change of direction of travel.

12.10 The speed of the vehicle shall be reduced gradually to the comfort of the passengers before entry to the terminal station. The reduction in speed shall be effected by an entry deceleration circuit.

12.11 For funicular railways which may be remotely controlled, two independent arrival monitoring systems shall be provided.

12.12 The arrival monitor shall activate the safety circuit to slow down or stop the vehicle if the speed of the vehicle has not been reduced to the permissible 0.7 m/s or less on its approach to the end switches.

12.13 Upon actuation of the arrival monitoring circuit, the vehicle must be brought to a complete halt in front of the buffers by the emergency brake.

12.14 The speed sensing device for at least one of the arrival monitors shall be driven directly by the driving drum or deflection sheave. The output signal from the speed sensing device shall be continuously monitored.

12.15 Additional safety device shall be provided after the end switches which will actuate the emergency brake.

12.16 For funicular railways with a speed of travel less than 2m/s, a speed-dependent arrival control is not required.

12.17 For manually controlled railways, the approach of the vehicle to the terminus shall be indicated by an audible signal in the control room.

12.18 Automatic stopping must occur as soon as any breakdown occurs in the safety or control circuits. No re-start shall be possible until the fault is cleared. The operation of any safety circuit shall be clearly annunciated in the control room giving information as to the type and location of the fault.

12.19 Emergency stop buttons provided at locations under Section 11.8, shall be distinguished by colour and label.

12.20 Bridging Circuits

(i) If a fault is occasioned by a breakdown or malfunction of the control circuitry it may be permissible, under certain circumstances, to by-pass that part of the circuit component with a bridging circuit. Any such devices should be correctly engineered and their functions clearly described in the design documentation. Their use, however, will be restricted to responsible staff and under no circumstances must their use prejudice safety.

(ii) The bridging circuit shall only be made possible by a key switch.

(iii) The travelling speed shall not exceed 2m/s during bridging of the control circuitry.

Part 13 Remote Monitoring System

13.1 If the travelling speed is greater than 5m/s, the haulage rope shall be monitored by a monitoring circuit.

13.2 Trackside and overhead signal cables which carry information relating to the railway safety shall be monitored by a monitoring circuit.

13.3 Stoppage of the funicular railway shall be initiated whenever the monitoring circuits are interrupted, short circuited with other monitoring circuit, or earthed.

13.4 Voltages up to 50 volts are allowed in the monitoring circuits between circuit and earth, and between circuit and circuit.

13.5 The vehicle shall be brought to stop by a monitoring circuit when the earthing resistance of the haulage rope drops below 500 ohms.

13.6 The activation of vehicle stop as mentioned in Section 13.5 may be delayed for at most 0.5 second to allow for accidental or temporary interruption, earthing or atmosphere effect.

13.7 The monitoring circuits shall have an impedance of not less than 20,000 ohms at a testing voltage of 500 volts.

Part 14 Communication

14.1 For manually controlled funicular railways with relatively straight and short track, one set of signalling equipment shall be sufficient.

14.2 A communication system between the driver in the driver cabin of the vehicle and the duty technician in the control room shall be provided. The communication or signalling equipment shall continue to work in the event of mains supply failure, application of any brakes, tripping of end switches or actuation of safety circuits.

14.3 If permanently applied current collectors are used for passing signals and instructions, those contact points or shoes shall be checked regularly for interruptions.

14.4 The vehicle shall be provided with a public address system that is audible at any point inside the vehicle. Annunciation informing passengers on action to be taken in the event of the vehicle coming to a halt between normal stopping places shall be given through the system. For vehicle without attendant, an intercommunication system between the passenger and the control room shall be provided.

Part 15 Vehicle

15.1 The design calculation of the structure and load bearing components of the vehicle shall take into account all anticipated static and dynamic forces that will be encountered in operation including:-

(i) vehicle own weight plus payload;

(ii) wind effect during operation;

(iii) impact force due to passenger loading and unloading;

(iv) braking force of service and emergency brake; and

(v) vehicle colliding buffers.

15.2 All components of the structure of the vehicle shall be easily accessible for inspection and maintenance. All internal and external surfaces shall be protected against corrosion.

15.3 The enclosure of the vehicle shall have the following provisions to ensure maximum safety to the passengers:

(a) Vehicle shall be provided with body panel up to 0.4m above the seating surface or 1.1m above the floor surface for cabin with standing passengers. Sharp edges and abrupt protrusion inside the vehicle and near the door openings shall be avoided. Body panel material may be metal or fibre glass.

(b) Enclosed vehicles shall be adequately ventilated by means of operable windows or mechanical ventilators. Windows shall be of non-splintering materials e.g. safety glass or synthetic plastic material;

(c) Doors shall be so secured that they can be opened only by a purposed action. For power operated doors, the closing force shall not exceed 150 N. The edges of the doors shall be buffered with a soft material. In case of power failure, the doors shall be kept locked and shall be capable of being opened by hand from both inside or outside of the vehicle with the aid of a key. Keys of this type shall be kept only by responsible persons;

(d) For vehicles which are unattended, all door opening mechanisms should be operated from the outside and shall not be able to be opened from inside;

(e) Folding doors shall be opened only into the vehicle. Doors which open outwards shall be secured by locking devices and can only be opened from the outside;

(f) The funicular railway shall not be operated for carrying passengers with the vehicle doors in the opening position;

(g) An emergency exit door, not on the same side as the normal exit door, shall be provided to give an adequate means of exit from the vehicle direct to the track in case of vehicle/system breakdown; and

(h) A separate compartment at both ends of the vehicle shall be provided for the driver.

15.4 The maximum permitted number of persons and the live load in kg to be carried by each vehicle shall be conspicuously displayed in all vehicles.

15.5 The passenger carrying capacity shall be calculated as follows:-

(a) For seated passengers:

Seat width : 0.4 m

Seating pitch : 0.7 m

(b) For standing passengers:

Floor area of 0.25 m^2 for each standing passenger.

(c) Standing passengers are allowed provided that at no time during the whole journey the slope of the floor allocated for standing passengers exceeds an angle of 15^o to the true horizontal.

15.6 Vehicles that allow standing passengers shall be provided with adequate handrails etc. Unattended vehicles shall be equipped with a device which indicates that there is an overload. This should be interlocked with the starting mechanism.

15.7 The vehicle shall be provided with an independent track braking system capable of stopping and holding indefinitely the vehicle at any location on the track and shall be actuated automatically when :-

(a) failure of haulage rope;

(b) excessive slack in haulage rope, that is when the traction force of the rope is less than 3 kN; or

(c) vehicle exceeding its maximum permissible speed by 30 %.

15.8 All vehicle parts shall be connected together electrically and shall be earthed. Only low voltage electrical appliances shall be used in the vehicle.

15.9 If the vehicle has two compartments, they shall be connected by a double fastening, each having a minimum factor of safety of 6. Each compartment shall also be provided with an emergency track brake of its own.

15.10 The track brake shall be capable of operation, by the vehicle attendant, from the control console in the vehicle. All components of the track brake shall have a factor of safety of at least 2 against the tensile yield strength.

15.11 The direction of travel and speed may be controlled from the vehicle. The instructions to proceed shall be made subordinate to instructions to stop and to instructions to reduce speed.

15.12 Vehicles shall be fitted with interior lighting and headlamps, and shall be earthed. Flooring shall be of non-slippery material.

15.13 Vehicles shall be numbered or coloured for identification.

15.14 All switches, controllers, meters and lamps on the control console in the vehicles shall be clearly labelled, in English and Chinese, as to their functions.

Part 16 Track

16.1 The track, including rails, switches, sleepers, foundation and any bridges, shall be so designed, constructed and maintained to absorb any forces from the vehicles under the most adverse conditions of loading and during emergency braking, without undue deflection or permanent deformation.

16.2 After every application of the vehicle track brakes, the track shall be inspected by experienced technical personnel in details, in particular the 50 metres length on either side of the point of application of the track brakes.

16.3 The track shall be kept clear at all times of debris, soil and rocks, so allowing free passage of the vehicles and causing no impediment to the natural drainage along the track.

16.4 The track shall be laid in the straightest possible manner and with the most even angle of inclination possible.

16.5 Lateral curve radii shall be as large as possible. They shall be at least $6V^2$ in metre, where V is the speed of vehicle in m/s, and shall not be less than 100 metres.

16.6 Means shall be provided to keep the haulage rope in touch with the rollers at all times even where the track has a concave profile.

16.7 The track shall be protected from unauthorized access as far as practicable.

16.8 A walkway shall be provided along the whole length of the track. Where this is not practical, proper means of emergency evacuation from the vehicles shall always be provided.

16.9 At the ends of the track, inspection pits shall preferably be provided in which work can be carried out by maintenance staff in an upright position. In order to protect the safety of staff working in the pit, the following safety installation shall be provided:

(i) an emergency stop switch inside the pit to stop the vehicle through the activation of the emergency brake or the service brake; or

(ii) a master switch within the control panel of the vehicle which will be locked off during the maintenance work and the key is to be kept by staff working at the pit.

Part 17 End Buffers

17.1 The distance between the buffer and the normal stopping position of the vehicle shall be at least equal to the braking distance with the application of the emergency brake.

17.2 The capacity of the buffers shall be designed to be capable of absorbing the kinetic energy of the vehicle under loaded condition. The permissible 0.7 m/s or less, as mentioned in Section 12.12, shall be used for calculating the kinetic energy as well as the braking distance mentioned in Section 17.1.

Part 18 Stations

18.1 The drive and control equipment shall be housed in purposely designed plant rooms. One terminal station shall include a workshop and storerooms. The building structures and facilities shall be constructed with reference to the Buildings Ordinance (Cap. 123). The design of the terminal buildings shall take account of all the imposed forces, including rope tensions and an earthquake loading as indicated in Section 3.3, lightning protection shall be in accordance with BS 6651: 1999.

18.2 The layout and disposition of the stations shall be such that the access and exit points are clear, even at times of maximum passenger flow. The circulation of passengers is, as far as possible, unhindered. Sufficient covered space shall be provided, under average passenger flow conditions, for waiting passengers.

18.3 The width of the station embarking platforms shall be at least one metre wider than that of the vehicle body. However, if the station is manned with staff for controlling the passengers, and with additional waiting area, the width of the embarking platform can be suitably reduced. When passenger flow is low at intermediate stations, the width of those platforms shall be at least 1.2m.

18.4 The clearance between the edge of the platform and the door opening of the vehicle shall preferably not exceed 50 mm.

18.5 Passengers shall not have access to any area housing machinery or operational equipment and shall be given access only to the boarding and alighting areas.

18.6 Notices to the passengers shall be posted in conspicuous positions and shall be written in both Chinese and English. Pictograms are allowed. Entry and exit points in a station shall be clearly illustrated.

18.7 Adequate lighting either natural or artificial, shall be provided for public areas, machine room, control room and maintenance areas.

Emergency lighting shall be available from a secure supply. Such supply should conform to the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection and Testing of Installations and Equipment issued by Fire Services Department.

18.8 Upon receipt of building plans, Director of Fire Services will be responsible for formulating requirements/recommendations for the intended use of such terminal stations. In addition, proper management of terminal stations with specific reference to good

housekeeping, effective control of passengers, unobstructed entrances/exits, etc. are essential for prevention of fire. Any such requirement of the Director of Fire Services shall be complied with.

Section B Operation and Maintenance

Part 19 Scope

19.1 This section of the Code of Practice is intended to give guidelines on the operation and maintenance aspects of the funicular railways.

19.2 It is not the intention of this section to prohibit the adoption of innovative and improved operation and maintenance practices. However, all such practices should be supported by proven field applications.

19.3 The Director will make revision to this section from time to time to suit the technological development in the field of funicular railways.

Part 20 Test Trip and Daily Tests

20.1 Before commencement of daily operation, and after stoppage of the funicular railway due to inclement weather conditions such as typhoon, a test trip without passenger shall be carried out. The following conditions must be observed:-

(i) the laying of the rope and the running of the rope in rollers; and

(ii) the clearance of trees and obstacles from the track.

20.2 The daily tests shall comprise at least the following:-

(i) the functioning of the safety circuit and monitoring circuit;

(ii) the indicated current readings and the signals of remote monitoring installations;

(iii) the functioning of intercommunication system;

(iv) the accessibility of all emergency stop button or switch;

(v) the functioning of door monitoring system;

(vi) the laying of rope in rollers and sheaves;

(vii) the condition of the brake;

(viii) the condition of the hydraulic system and main drive;

(ix) the functioning of load measuring equipment, if installed; and

(x) the functioning of the public address system.

Part 21 Weekly Inspection of Haulage Rope

21.1 The visual inspection of the haulage rope shall be carried out weekly at maximum inspection speed of 2.5m/s, or with testing apparatus.

Part 22 Monthly Inspection and Testing

22.1 Monthly Inspection

The monthly inspection shall cover at least inspection on:-

(i) the wear of grooves of the sheaves, rollers, and brake shoes;

(ii) the pressure accumulators of the hydraulic or pneumatic system;

(iii) the conditions of vehicles, including the car coupling, rope fastening, door locks and emergency door release; and

(iv) the condition of the track brakes of the vehicle.

22.2 Monthly testing

The monthly testing shall at least include testing on:-

(i) the service and the emergency brakes;

(ii) the arrival monitors in both directions;

(iii) the rope monitoring circuits under short circuit, earthing or interruption conditions; and

(iv) the entry deceleration circuit.

Part 23 Quarterly Inspection and Testing

23.1 The quarterly inspection and testing shall cover at least:-

(i) testing of the slack rope switch;

(ii) inspection of the conditions of track bed, viaducts, bridges, cuttings, embankments, cross drainage and station works.

Part 24 Annual Survey

24.1 The annual survey, which shall be performed by an approved surveyor, shall cover at least the following items:-

(i) the normal operating data and general condition of the installation;

(ii) checking of main gearbox for lubrication and measurement of backlash;

(iii) checking of main haulage drum shaft and output shaft for clearance;

(iv) checking of haulage drum and deflection sheaves for surface cracks or defects;

(v) checking of overload protection for motors and generator;

(vi) checking of hydraulic circuit for correct pressure settings and testing of their function;

(vii) checking and testing of safety devices installed at terminal including the vehicle position indicators and over-travel limit switches;

(viii) checking and testing of electrical safety circuit;

(ix) checking of rope monitoring circuit;

(x) checking of arrival monitors and the associated control circuit;

(xi) checking of overspeed protection at 10%, 15% and 25% overspeed;

(xii) checking of electrical installation at the intermediate stations and along the route;

(xiii) checking of lightning protection at terminals;

(xiv) testing of service brake and emergency brake in control room;

(xv) testing of service brake and emergency brake upon activation in vehicle with one vehicle fully loaded, another empty,

travelling at rated speed, in both directions of travel. Record the braking distance and time;

(xvi) checking and testing of the track brakes installed in both vehicles with the tested vehicle fully loaded, another empty, travelling at reduced speed at the steepest slope of the track. Record the braking distance and time for each vehicle;

(xvii) checking of haulage ropes by taking measurement of the diameter of some sections of the rope, visual inspection of the condition of the rope, and taking the defectograph reading of the rope;

(xviii) checking of vehicle for corrosion, deformation or damages;

(xix) checking of tightness of bolts and rivets in vehicle;

(xx) checking the condition of the track and its structure such as bridges, for looseness of bolts, corrosion, and deformation;

(xxi) checking of rollers along the track for wear and misalignment;

(xxii) checking the stability of slope, embankment and protective walls along the track;

(xxiii) checking of force bearing components in stations and machine room; and

(xxiv) recommendations to improve the safety standard of the installation.

Reference

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4. Kemp's Engineering Handbook.

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6. British Standard BS 5266-1: 1999. Emergency Lighting. Code of practice for the emergency lighting of premises other than cinemas and certain other specified premises used for entertainment.

7. Aerial Ropeways and Funicular Railways. Z. Schneigert.

8. British Standard CP 3 (Chapter V - Loading). Basic Data for the Design of Buildings.

9. Laws of Hong Kong. Buildings Ordinance (Cap. 123), Building (Construction) Regulations (Cap. 123 Sub. Leg.), and Code of Practice (Wind Effects).

10. British Standard BS 302-5: 1987. Specification for ropes for haulage purposes.

11. British Standard BS 6651: 1999. Code of practice for protection of structures against lightning.

12. Code of Practice for the Electricity (Wiring) Regulations (1997 Edition).

13. Laws of Hong Kong. Fire Services Ordinance (Cap. 95), Fire Services (Installation and Equipment) Regulations (Cap. 95 Sub. Leg.), and Code of Practice for Minimum Fire Service Installations and Equipment, and Inspection and Testing of Installations and Equipment issued by Fire Services Department.