CHAPTER 7 RISK ASSESSMENT AND MITIGATION MEASURE

7.1 GENERAL

A methodology is developed to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. Risk assessments include detailed Quantitative and Qualitative understanding of risk, its physical, social, economic and environmental factors and consequences. It is a necessary first step for any serious consideration of disaster reduction strategies.

Risk assessment encompasses the systematic use of available information to determine the likelihood of certain events occurring and the magnitude of their possible consequences. As a process, it is generally agreed that it includes:

- Identifying the nature, location, intensity and probability of a threat;
- Determining the existence and degree of vulnerabilities and exposure to those threats;
- Identifying the capacities and resources available to address or manage threats; and
- Determining acceptable levels of risk.

7.2 RISK

Risk is the probability that a substance or situation will produce harm under specified condition. Risk may be defined as:

- The probability of an event to occur
- The probability of a toxic substance to be released by an event.
- The probability of the adverse effects due to exposure of individual population, eco system or other factors to the harmful substance or material.

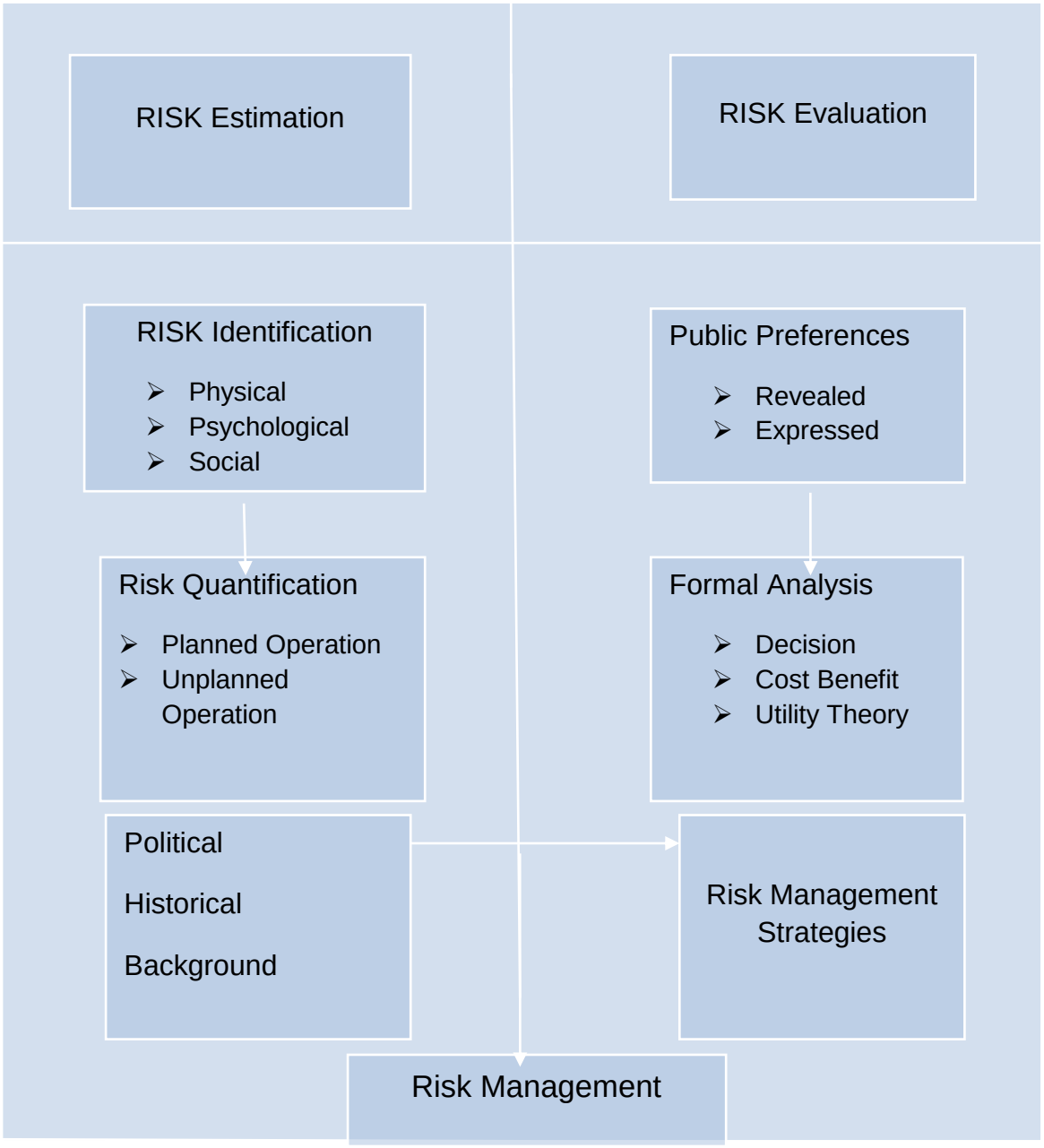
7.2.1 Risk Assessment

It is Quantitative or Qualitative analysis of the hazard and risk. It estimates the severity and likelihood of harm to any human life and the environment. Risk assessment is the use of the factual base to define health effects of exposure of individual or population to hazard material and situations. It is the identification of main hazard and unsafe practices in Ropeway and required preventive or remedial action. Risk Assessment framework are given in the **Figure 7.1.**

- Assessment of Structure (geographical/functional/process/flow)
- Identify Hazards and Risk based on information collected
- To monitor and audit management policies, procedures and performance to secure safety in work place
- Requirement of safety legislation and guidance
- Preparation of safety policies
- To identify potential problems
- To investigate accidents
- Record the assessment
- Measurement the effectiveness of action

- To prevent undesired accidents
- To prepare reports
- Monitor and Review the program of Risk assessment

Figure 7.1: Risk Assessment Framework



7.2.2 Risk Characteristics

It includes the estimation of health risk associated with the process under investigation. The result of this characteristic is a number that represents the probability of adverse health effects from that accident or operation of Ropeway.

7.2.3 Risk Management

Risk management uses information from risk identification and risk assessment along with the information of technical resources, social economic value and information to reduce and control any identified hazard. It also involves design and implementation of policies and strategies resulting from decision process making.

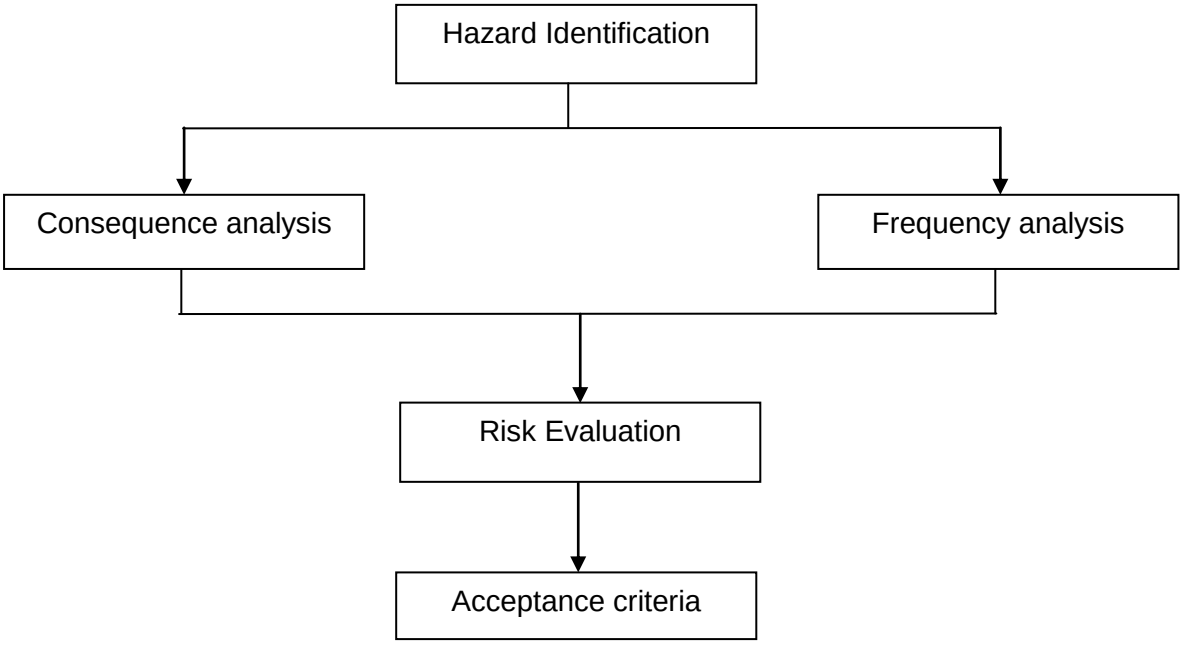
7.2.4 Risk Communication

Risk communication is the exchange of information between the general public and the concerned authority about the risk perceived and to reduce, control, and prevent accident. Risk communication can be done with the detailed information of the assessed risk which is documented and forwarded to staff and responsible person. Signs and symbols can be put up to prevent illegal entry into unsafe areas.

7.2.5 Risk Assessment Methodology

Risk assessment is an appraisal of both the kinds and degree of threat posed by an environmental hazard. Such appraisal includes the recognition of hazard, the measurement of threat and understanding of the social meaning of such measurements. There is a need for preliminary practice of hazard identification before more and detailed appraisal takes place. There is also a need to broaden the concept to estimate and evaluate. The estimates of the likelihood of risk may relate to an event, to its consequences or both. Risk estimation may include quantified estimates of probability or nonqualified probabilistic estimates and these may reveal intuited or exploited from experience. Social evaluation of risk may seek to avoid some risk at all cost, balance (benefit-risk) and with other cost (Cost - Benefit). The five stages of Risk Assessment are given in the **Figure 7.2**.

Figure 7.2: The Five Stages Of Risk Assessment



Hazard

A hazard is defined as a "Condition, event, or circumstance that could lead to or contribute to an unplanned or undesirable event." Seldom does a single hazard cause an accident. More often, an accident occurs as the result of a sequence of causes. A hazard analysis will consider system state for its failures or malfunctions.

Nature has gifted human beings with power and means to negotiate distances and heights. Machines made their task easy and fast. Aerial ropeway is one such exclusive and simple mechanical system, which facilitates transport of man and material over difficult and abnormal terrain bringing about comparative ease and economy vis-à-vis other means of transport

- **Hazard Identification**

Hazard identification and risk assessment is a continual process. It is performed to identify whatever could cause injury, damage, ill-health, financial loss and loss of reputation to the organization. Hazard identification is an analysis to determine whether a risk agent under plausible conditions would cause harm to population or the environment. Hazard identification is an analysis which is in many ways a detailed study of operations and process, epidemiology, ergonomics. Hazard identification and risk assessment (HIRA) Objectives are to,

- Identify any thing that may cause injury, damage, ill-health]
- Prioritize the risks in terms of urgency of required attentions
- Discover preventive or mitigating actions that can be taken in each case
- Create awareness in all concerned in each and every factor and activity that may cause injury damage or ill health
- Enhance decision making by brining all concerned and effected parties into the HIRA process
- Encourage employees to take ownership of their own safety in terms of recognizing and reporting hazards and participating in the discovery and implementations of the solutions that will prevent incidents or mitigate the consequence
- Build a team approach to Safety Health and Environment Management

- **Risk Assessment**

Determine which hazards are more serious than others, so you can start dealing with those ones first. To assess the risk associated with hazards you have identified, ask the following questions:

- How likely is the hazard to cause harm to someone?
- What is the worst possible damage the hazard could cause in terms of human suffering and cost if you don't resolve the problem?
- How many people are exposed to the risk? Sometimes it may be the amount of time workers spend on an activity that creates the safety risk, rather than the nature of the work task itself. Everyone is different. A hazard may also pose more risk to some people more than others because of differences in physical strength, experience, training etc.

- **Risk Control**
  - Identify the underlying cause of hazards and put measures in place to prevent a recurrence of the risk

- Focus attention on the most urgent hazards, priorities the hazards using the risk management matrix, understanding that some methods are more effective than others.

  Use the highest-ranked control that is practicable for controlling risk, and only use the lower-ranked controls as a last resort or until a more effective way of controlling risk can be used. More than one control measure can be used to reduce the exposure to hazards, which are follows
- Eliminate the hazard
- Substitute the hazard with a safer alternative
- Isolate the hazard
- Use engineering controls
- Use administrative controls
- Use personal protective clothing and equipment (PPCE)

- **Review/Monitor-Evaluate the Results**

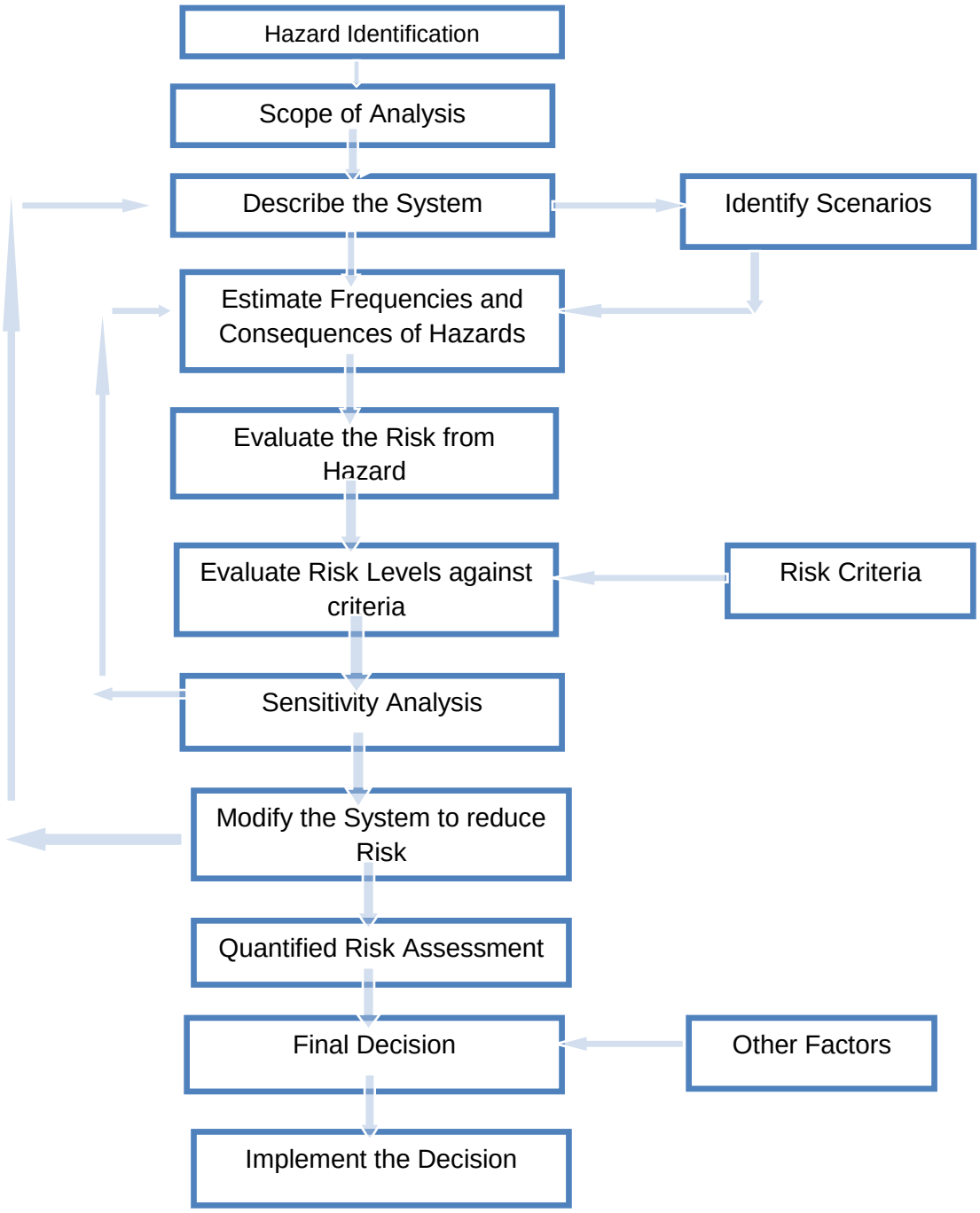
Review your safety solutions regularly to make sure they are effective, and making sure your controls do not introduce new hazards. To assess the success of your risk control methods:

- ✓ Talk to the people involved and look at your centre injury/accident records.
- ✓ Seek advice from those affected by the changes and consult with them Regarding any modifications
- ✓ Consider staff training needs, communicate with employers, managers, contractors and workers work together as all parties in the workplace havea legal responsibility for workplace health and safety

Risk assessment involves comparing likely exposure with likely effects. Both distributions are represented hypothetically as symmetrical but they need not be so. Precise probability effects could in principle, be computed from the extent of overlap of distribution. The main reason to specify risk is that they can be managed. From the prospective of environment risk assessment, decisions have to be taken about what to protect prior to an assessment being carried out. Decisions have to be taken about to what level protection will be exercised so that appropriate threshold levels can be defined. Management often involves balancing the advantages to the environment and human health by different options and with their consequences for other social benefits. The significant point is that risk is a function of two parameters; the likelihood of an occurrence of undesired event and its consequences. The procedure for Risk Assessment is given in the **Figure 7.3**.

Risk = f (Frequency x consequences)

Figure 7.3: Procedure For A Risk Assessment



7.2.6 Safeguarding of passengers and personnel – risk assessment methodology

For new installations or relocations, a risk assessment shall be performed. The risk assessment shall take into account the stage of development, intended use of the Passenger Ropeway, anticipated skill and training of personnel, additional risk exposure and reasonably foreseeable events or misuse. A number of methodologies are available to do a risk assessment. Any method is acceptable which prescribes safeguarding equivalent to or more stringent than the requirements of this annex. The risk assessment process shall be instituted during the system planning/design phase and continue throughout the system construction, operation, and

decommissioning. The risk assessment process shall emphasize the prevention of accidents by resolving hazards in a systematic manner as described below.
The hazard resolution process shall be initiated by defining the physical and functional characteristics of the Passenger Ropeway system to be analyzed. These characteristics shall be presented in terms of the people, procedures, facilities and equipment which are integrated to perform a specific operational task or function within a specific environment.
The hazards shall be identified. The techniques and methods used to identify the hazards shall include:

(1) Data from previous accidents or operating experience
(2) Expert opinion and hazard scenarios
(3) Checklists of potential hazards
(4) Previous hazard analyses
(5) Other analysis techniques as appropriate

All identified hazards shall be assessed in terms of the severity or consequence of the hazard and the probability of occurrence. This shall be accomplished in general accordance with the criteria outlined herein or equivalent.

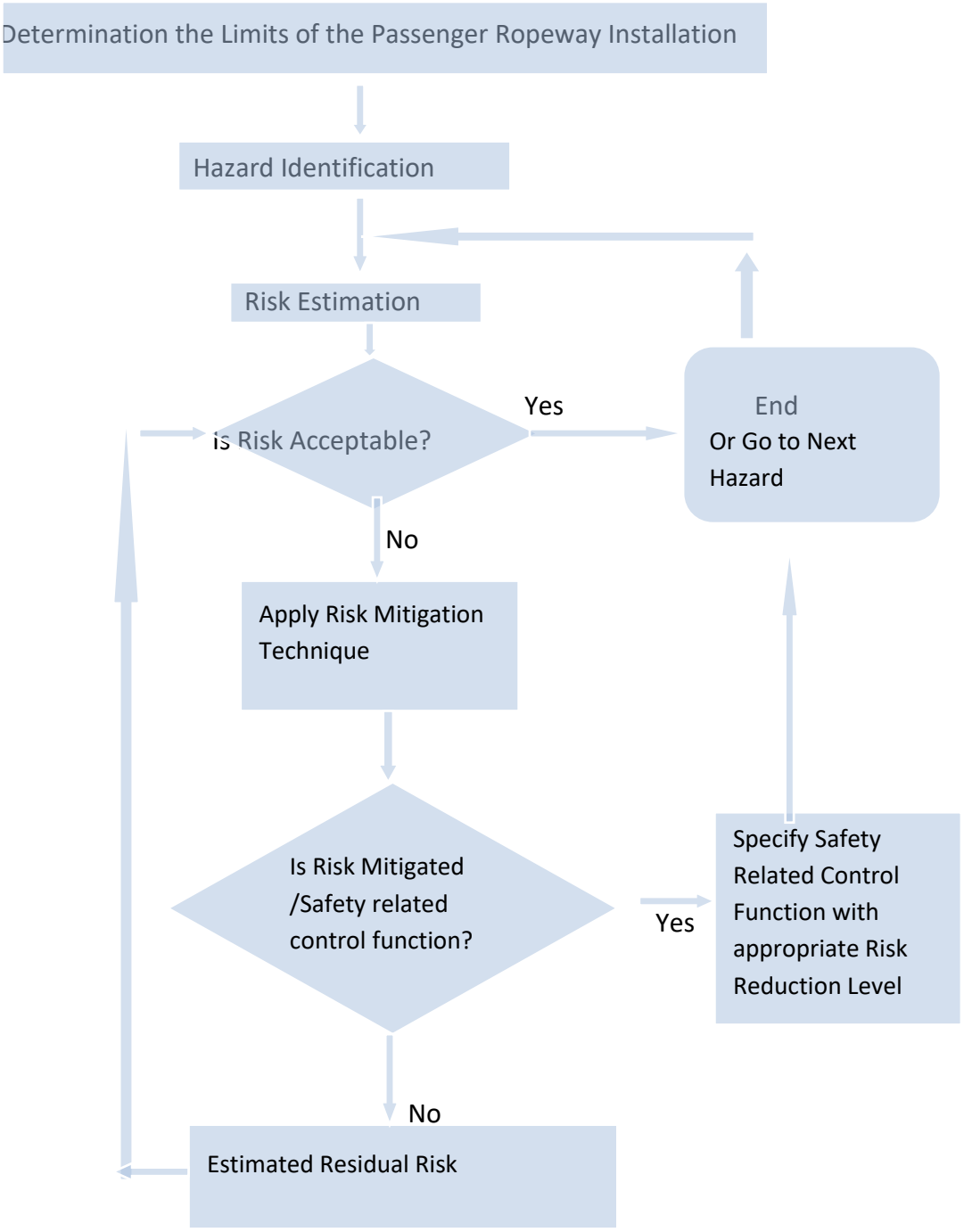
Risk assessment estimates shall be used as the basis in the decision-making process to determine whether individual system or subsystem hazards shall be eliminated, mitigated, or accepted. Hazards shall be resolved through a design process that emphasizes the elimination of the hazard. For all other hazard resolution strategies, or safeguards, the following hierarchy of controls shall be employed, in order of effectiveness (most to least);

(1) Design by hazard elimination or substitution
(2) Engineered Safeguards
(3) Awareness means
(4) Administrative controls (Training and Procedures)
(5) Personal Protective Equipment
(6) Acceptance of the residual risk / Information for use concerning the residual risk.

This process shall include full documentation of the hazard resolution activities. The effectiveness of the safeguards shall be monitored to determine that no new hazards are introduced. In addition, whenever substantive changes are made to the system, analyses shall be conducted to identify and resolve any new hazards introduced.

Where risk mitigation techniques and safeguarding methods are previously prescribed by various sections in this standard, the risk assessment shall serve as a method for determining suitable application according to the “hierarchy of controls” as well as functional safety circuit performance requirements as applicable. This method may be utilized to assess the applicability of a safeguard according to variable conditions or characteristics for a particular application which is shown in **Figure 7.4**.

Figure 7.4: Risk Assessment Flow Chart For Limits Of Passenger Ropeway Installation



7.3 ROPEWAY ACCIDENTS HISTORY

7.3.1 Wire Rope Failure Accidents in Cableway/ropeway industry

- March 1999, Italy, Cavalese ropeway, wire rope snapped and caused 20 persons died.
- July 1st 1999, west France, The Alps ropeway, wire rope snapped and caused 21 astronomers died.
- Oct 3, 1999, P. R. China, Gui Zhou Ma Ling ropeway, wire rope snapped and caused 14 persons died, 22 people injured.
- Jan 19, 2003, Indian, Pavagadh Ropeway, wire rope snapped and caused 7 person died, 42 person injured.

- On 19 October 2003. Darjeeling Rungeet Valley Ropeway Four tourists were killed and 11 others injured. The carriages, with the passengers, crashed and rolled into the steep tea garden slopes nearly 100 ft below.

One of the reasons for the accident was a change in alignment of the ropeway following a shift in the mountains

- Oct 16, 2006, P. R. China, Guang Xi Wu Zhou ropeway, wire rope snapped and caused 5 persons died.
- Aug 27, 2007 India Palani hill shrine Four persons, including three of a family, were killed and two boys seriously injured when a cabin of a ropeway car hit another on the way.
- Feb 21, 2009, India Chadayamangalam Jadayu Rock ropeway, wire rope snapped and caused 1 person died.

7.3.2 Wire Rope Failure Accidents in Hoisting industry

- May 24, 2002, the steel rope carrying the helicopter's load had snapped and caught in the rotor blades, bringing the helicopter came down off Orkney, UK, a pilot killed in this accident.
- Feb 20, 2006, the wire rope snapped at a well-intervention vessel operated by the oilfield services company, UK, 1 worker died.
- July 12, 2007, the crane wire rope snapped at New Delhi's metro caused the entire structure tumbled down in a V-shaped pile, crushing workers underneath. Six people were killed and 13 injured. 3 cranes crashed.
- Aug 2, 2007, A Sydney judge has proposed awarding damages of $1.4 million to a Navy reservist in Western Australia who fell from a high ropes course when a safety cable broke.
- July 23, 2008, James Dawes of Topeka, Illinois, was killed after being struck by the boom of a Link-Belt crane, operated by Area Erectors. The accident was caused by the boom hoist wire rope breaking, dropping the boom onto the aerial lift in which Dawes was working.
- Dec 15, 2008, Shen Yang coal group Hong Ling coal mine, wire rope snapped and caused 1 person died.
- Jan 1, 2009, New Brighton Pier, a steel cable snapped and 1 person seriously injured.
- May 20, 2009, a crane wire rope snapped at Chang Zheng coal mine, Gan Su, 1 person died and 26 people seriously injured.
- Apr 22, 2009, a wire rope snapped at Yu Tan gold mine, De Xing and 2 people died.

7.3.3 Wire Rope Failure Accidents in Elevator industry

- May 29, 2006, the elevator cable snapped and caused the elevator plunked in Ukraine transport ministry building, 11 people seriously injured.
- May 30, 2007, the elevator cable snapped and caused the elevator plunked in a company at Nei Jing, Si Chan, P. R. China, 3 people died.
- Aug 5, 2008, the elevator cable snapped and caused the elevator plunked in a building of Salt Lake city, Utah, USA. One person injured.

- Oct 30, 2008, the elevator cable snapped and caused the elevator plunked in the building site of Yang Guang Cheng, Xia Pu, Fu Jian, P. R. China, 12 people died in this accident.
- Jun 23, 2008, the elevator cable snapped and caused the elevator plunked in Las Vegas hotel, Nevada, USA, A 60 years old man injured.
- Dec 27, 2008, the elevator cable snapped and caused the elevator plunked in a construction site at Shang Hai Cheng, Chang Sha, Hu Nan, P. R. China, 17 people died, 1person seriously injured.
- Feb 19 2009, the elevator cable snapped and caused the elevator plunked in a construction site at He Fei, P. R. China, 2 people died and 2 people injured.
- May 11, 2009, Six people were injured in an incident caused by a snapped cable in a lift inside London's Tower Bridge.

7.4 FIVE MAJOR PROBLEMS IN USE OF WIRE ROPES

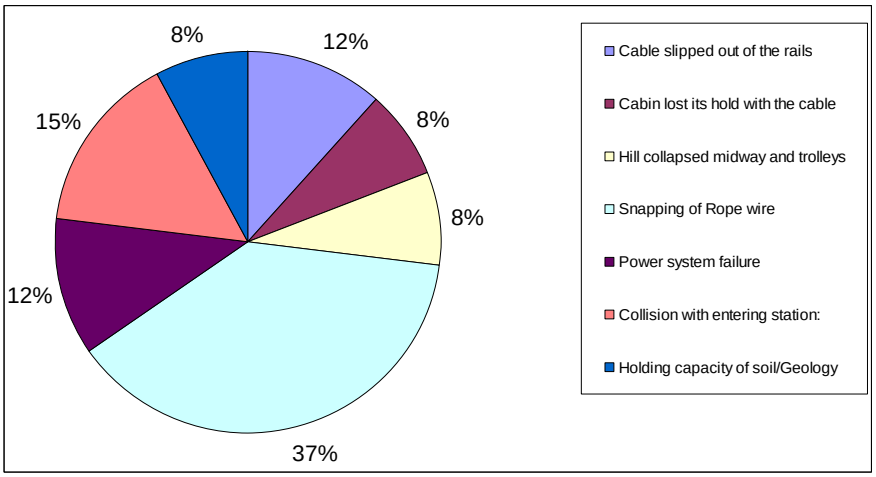
- Unsafe: Wire breakage accidents caused by strength loss always exist in the use of wire ropes. According to survey conducted by USA authority organization, 12% in-service wire ropes in 8,000 wire rope users are in "extremely dangerous" situation.
- Diseconomy: Regular replacement of wire ropes causes huge waste. The statistics from USA indicates that 70% of those compulsively replaced wire ropes have just little strength loss.
- Inefficiency: Traditional visual inspection method costs more time and labor, and low efficiency.
- Unreliable: Manual inspection is not reliable and many hidden dangers cannot be detected.
- Serious danger: Serious wire breakage accident inevitably caused serious damage. According to statistics of State Administration Bureau of Safety Production Supervision China, there were 1065 accidents related to wire rope breakage in Chinese coal mine industry in year 2004 and 2005, causing 1142 persons dead. The most serious accident caused 14 persons dead and 5 seriously wounded.

7.5 IDENTIFIED HAZARD

1. Cable slips out of the rails at the tower from the upper station can cause the carriages to be knocked off. The accidents take place due to negligence.
2. Cabin loses its hold with the cable and collided with the another one cabin of ropeway car and hit another on the way,
3. Hill collapses midway and trolleys are dangling in the air.
4. Power system failure
5. Collision with entering station: operator failes to slow the vehicle down upon entering the station which causes collision of the ropeway car at the entering station
6. Holding capacity of Soil/Geology
7. Flood
8. Soil Erosion
9. Earthquake
10. Landslide

Figure 7.5, Pie chart showing probable percentage causes of accident in Ropeway.

Figure 7.5: Probable Percentage Causes Of Accident In Ropeway



7.6 CONSEQUENCES AND FREQUENCY ANALYSIS

Table 7.1 is described with cause of hazard, their consequences and probable occurrences during the operation of the passenger ropeways. The assessment is based on the past incidence of occurrences. This helps to pay attention to a particular risk with appropriate mitigation measures.

Table 7.1: Hazard, Consequences and Probable Occurrences

Cause of Hazard	Consequences	Frequency Probable Percentage)
Cable slipped	Passenger death and material fall down	**12**
Cabin lost its hold with the cable	Passenger death and material fall down	**8**
Hill collapsed	Entire system fail and higher percentage of death	**8**
Snapping of Rope wire	Passenger death, and material fall down	**37**
Power system failure	Delay in operation	**12**
Collision with entering station	Small injury	**15**
Holding capacity of soil/Geology	Tower collapse & passenger death/Material fall	**8**
		100

7.7 ACCEPTANCE CRITERIA

In a regulatory context requirements for acceptance criteria are usually kept very general. Basically, there are only qualitative definitions of the risk acceptability limit such as:

- The industrial activity should not impose any risks which can be reasonably avoided,
- The costs of avoiding risks should not be disproportionate to the benefits,
- The risks of catastrophic accidents should be a small in proportion of the total.

Risk contains, by definition, both the Probability of Failure (PoF) and Consequence of Failure (CoF) aspects. For the regulatory perspective the introduction of the consequence element enables a risk-based inspection or maintenance procedure to get acceptance by the authorities. **Table 7.2** describes the acceptance criteria for seven types of hazard likely to occur during the operation of ropeways.

Table 7.2: Acceptance Criteria

Cause of Hazard	Acceptance Criteria
Cable slipped	High Risk
Cabin lost its hold with the cable	High Risk
Hill collapsed	High Risk
Snapping of Rope wire	High Risk
Power system failure	Low Risk
Collision with entering station	Low Risk
Holding capacity of soil/Geology	High Risk

A. Individual Risk

A formal definition of Individual Risk is expressed as the frequency at which an individual may be expected to sustain a given level of harm from the realization of specific hazards. It is usually taken to be the risk of death, and normally expressed as risk per year.

Individual Risk is the risk experienced by a single individual in a given time period. It reflects the severity of hazards and the amount of time the individual is in proximity to them. There are typically three different types of Individual Risks:

- **Location-Specific Individual Risk (LSIR):**Risk for an individual who is present at a particular location 24 hours a day, and 365 days a year. LSIR is not a realistic risk as the individual does not usually remain at the same location all the time and is not exposed to the same risk all the time.
- **Individual-Specific Individual Risk (ISIR):** Risk for an individual who is present at different locations during different periods.ISIR is more realistic than LSIR.
- **Average Individual Risk (AIR):**AIR is calculated from historical data a number of fatalities per year divided by the number of people at risk.

Individual Risks are also commonly expressed by means of the Fatal Accident Rate (FAR), which is the number of fatalities per 108 hours of exposure. FARs are typically in the range from 1 to 30, and are more convenient and more readily understandable than Individual Risks per year.

B. Societal Risk

A formal definition of the Societal Risk is given in as the frequency and the number of people suffering a given level of harm from the realisation of specified hazards. It usually refers to the risk of death, and expressed as risk per year.
This expression of risk is useful to limit the risks of catastrophes affecting many people at one time. Societal risks may be expressed as risk per year.

C. Area Risk

A third often-used measure of risk is the Area Risk. This measure is very useful when more than one source contribute to the overall risk of certain geographical area.

D. Environmental Risk

Environmental Risk includes short term and long-term effects to the biosphere. Here the affected area in m^2 (soil, ground and surface water) or the amount of released dangerous substances to the environment per year can be an adequate measure. Due to the fact that there are also financial aspects linked to the environmental risk, which can be measured in money (like cleanup costs, penalties, negative media publicity, etc.), these are best covered when evaluating the Economic Risk.

7.8 MTIGATION MEASURES

7.8.1 Design Verification

Aerial ropeways drawings are to be submitted to a recognized design verifier, before fabrication, construction, inspection, testing and certification. Design verifier may be an accredited inspection body, or, in-house recognized ISO 9001 designer's quality management system. These inspected drawings will include:

- Profiles of installation, specification particulars sheet, and rope specification details;
- Dimensioned drawings of main structural towers to show construction of top and bottom terminals, bull wheels, sheave batteries and tensioning arrangements;
- Calculations for stress analysis of critical parts of the structure, showing magnitude and direction of rope forces on all towers at the top and bottom terminal structures supporting the ropeway. The various individual loading conditions and factors from which, the rope forces are derived and identified; and
- Design checks are carried out by recognized design verifiers are of structures and equipment supporting the loads imposed by the ropeway system, e.g. terminal station sheaves and support structures, towers, sheave batteries, and are in terms of factors of safety.

7.8.2 Acceptance

While starting operation of a passenger ropeway is placed in, it shall be subjected to commissioning inspection and testing. Thorough tests shall be made under loadings which provide the most unfavorable conditions, where practicable. This shall include an operational check of motive power, acceleration, deceleration, all brakes, all push-button stops, and all automatic stops and limit switches, and all communication devices. Prior to acceptance tests the passenger ropeway shall be run for a full day, and checked for overheating of moving parts, excessive vibration or deflection, free movement of counterweights, etc.

7.8.3 Materials

Choice, quality testing, and use of materials for aerial ropeways shall be in accordance with the appropriate Bureau of Indian Standard, noting that for load-bearing parts, including towers, and drive and return terminal structures, the materials are to comply with the low temperature impact properties for the minimum operating ambient site temperature. The design, details, materials and construction features shall provide safety factors at least

equivalent to those specified of Indian Standard. The ropes used shall conform to the relevant Indian Standards (IS 7649). As far as possible, all wire ropes shall be in single piece and 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.

7.8.4 Foundation of Towers

The foundations of either tensioning devices or those of the anchorage shall be either rash allow foundation or deep foundation or founded on rock anchors. These foundations shall be in accordance with IS4091. For the structural safety against sliding, overturning and for the footing sat different levels provisions lay down inIS:1904 shall apply. The depth of footings and other provisions shall conform the provisions laid down in the relevant Indian Standards depending on the type of foundation. [Refer IS 1904,IS1080,IS2950,IS11089,IS9456,IS2911(Part1/Sec1),IS2911(Part1/Sec2),IS2911(Part1/Sec3),IS2911(Part1/Sec 4), IS 2911 (Part 3)] These foundations shall be in accordance with Code of Practice for Design and Construction of Foundations for Transmission lines Towers and Poles IS 4091. For the structural safety against sliding, overturning and for the footings at different levels provisions lay down in IS 1904 shall apply.

Construction of structures be avoided on the steep and dip slopes. Light structures are preferable where the structure will be founded on cohesion less material or in highly weathered foundation rock. Weathered/shear portion be removed and treated by use of a thick mat of rein-forced concrete or by providing thick cement base on fresh surface. Construction of civil structures be avoided where water zones are available in the bed rock within foundation level. In loose soil, exposed on steep slopes, structures be avoided and if un-avoidable, deep foundation with protective works and drainage network is suggested. Easing of slopes, with proper grading and buttress walls are also recommended. Constructions of big buildings are preferable where topographic slopes would not exceed 25^0 Plate load tests are suggested to ascertain the amount and type of settlement where heavy structures are to be constructed.

7.8.5 Maximum Speed and Minimum Spacing between Cabin

The maximum speed of the Cabin at the station shall not be more than 1.5 m/s. The maximum speed of the Cabins along the line may reach 3m/s provided that the variation of speed on account of the requirements of route alignment of the ropeways between two terminals. This will not give rise to dangerous oscillations of Cabins.

In order to ensure the free movement of passengers and personnel in the station, the side clearance between the spaces occupied by a Cabin and fixed obstacles belonging to the installation shall not be less than 0.40 m measured towards the interior of the line.

Such clearance shall be 0.5m measured towards the outside of the line. In case there are no guides for Cabin, such clearance shall be maintained even when the vehicle is inclined transversally at 12°.
Along the line the distance between the two path soft ravel of the carrying-hauling rope shall be such as toensurea clearance of at least 0.5m between Cabins swung by 12° toward so nean other. Such clearance shall be required for span shaving a length of not more than 200 m. For

longer spans; the clearance shall be increased by 0.20 m for each additional 100 m or fraction thereof.

A minimum clearance of 0.30 m between the space occupied by a loaded vehicles wung longitudinally by 15° and obstacles lying on the vertical longitudinal plane shall be ensured either along the line or in the stations.

7.8.6 Wind Effects

The wind forces and their effects (static and dynamic) should be taken into account when designing ropeways. The provisions mentioned in IS 875 (part 3), IS 802 (Part 1) - shall be followed. The ropeway design shall also consider seismic loads in accordance with IS 1893. In addition, other special loads in accordance with IS 875 (part 5) shall also be considered while designing ropeway. The trestle shall be analyzed and designed for various load combinations as per IS: 802

In areas subjected to storms and where the wind velocity exceeds frequently 150 km/h, it is necessary to assume the pressure of the wind as the maximum value ascertained in the area taken into consideration.

The tubes used in the hangers shall have no longitudinal welds and preferably seamless. Their interior shall be protected against corrosion. If welded tubes are used, welding should be checked by Non-Destructive Testing (NDT).

Aerial ropeways shall be closed down when the wind velocity reaches the design limit values, as agreed by the design verifier, the lift manufacturer and the lift controller, for the particular operating conditions and particular lift installation. For this purpose, suitable wind gauges like anemometer shall be installed at appropriate locations to ascertain wind velocity.

7.8.7 Inspection and Testing of Aerial Ropeways

The inspection and testing of an aerial ropeway shall include the following:

- Visual examination of towers and machinery, for workmanship and correct installation in accordance with plans and specifications;
- The operation of the ropeway for a full day continuously to check for overheating of moving parts, excessive vibration or deflection of mechanical or structural components, free movement of tensioning system, etc.;
- Checking of operational controls for correct functioning, including manually operated stop switches, automatic stop switches, limit switches, de-ropement switches, brakes, antiroll back devices, over speed governor, under main and auxiliary power;
- Thorough operating tests under full load and any partial loading which may provide the most adverse operating system.

7.9 RULES OF PRACTICE FOR PASSENGER ROPEWAYS

Conditions In Terms of Load

- Overload tests on service brake, emergency brake and drive equipment simulating

10% overload conditions;

- Tests to establish the ability of the prime mover to start the ropeway under the most unfavorable loading conditions in main and auxiliary power;
- Check of all communication and alarm devices;
- Unless previous tests are documented, chairs and cabins, together with hangers, shall be tested as a unit with weight equal to twice their passenger-carrying capacity. While the weights are in place, all attachments to the chairs or cabins under tension shall be proven safe. The mass of a passenger shall be taken 80Kg.
- Any other tests which the inspection body may consider necessary, or the manufacturer recommends; and
- Record of all tests and inspections shall be maintained.

The manufacturer or the designer shall submit a complete schedule of all proposed acceptance tests to the design verifier before such tests are performed. This schedule shall then be forwarded to the equipment inspector attending the commissioning.

In the event of disputes over testing requirements, reference shall be made to Occupational Safety and Health. Inspections of a passenger ropeway will take place during its construction and periodically throughout its lifecycle regardless of when the inspection occurs.

Safety Officers may use the following tools:

- Helmet,
- Hand tachometer,
- Level,
- Digital camera,
- Dynamometer,
- Stop watch,
- Inclinometer (to measure angles of slopes), and
- Ski boots and skis are other pieces of equipment

The Safety Officers use above tools during the operational inspection and testing of passenger ropeways. Approved fall arrest equipment (Zula) is mandatory when Safety Officers are climbing towers and onto the passenger ropeway station.

Suggested test: The following parts should undergo test Loading test, Main drive, Rollback, Brake performance, Service brake, Emergency brake, Auxiliary drive, Emergency drive, Unload carriers: Demonstration of evacuation system.

7.10 OPERATION AND MAINTENANCEOF ROPEWAY

All equipment covered by BIS Code of Practice shall be maintained in a safe condition. A systematic routine maintenance and inspection schedule, based on a maintenance and inspection plan, which shall be specified by the designer shall be developed and set down in writing by the manufacturer of the passenger ropeway.

The schedule shall include the specification of lubricant and frequency of lubrication of each element involving moving parts. It shall stipulate that parts showing excessive wear shall be replaced immediately. Condemning limits or tolerances shall be defined. It shall include a schedule for checking and tightening all bolts, especially on rope attachments. For any

passenger ropeway, records of the rates of deterioration (such as corrosion, erosion, etc.) shall be maintained. During a periodic inspection (Monthly), a Safety Officer appointed by operators of ropeway may inspect towers, sheave assemblies, brakes and braking functions, and the operation of main drives, auxiliary drives, and evacuation drives. Periodic inspections will take place at any time of the year. Although these will occur during the ski season while the ropeway is in operation, inspections can also take place before the winter months. Safety Officers can conduct more inspections when the ropeway are not in operation or open to the public. This would include riding the maintenance-work carrier to check the towers on the line. The fuel supply for IC engines shall be checked regularly as appropriate for the fuel tank size and the usage. For primary power units, there shall be sufficient fuel to conduct the anticipated period of operation and to deal with all emergencies without refueling. Power units shall be shut down during the refueling.

Starting of ropeways

Only competent persons authorized by the ropeway management shall start a passenger ropeway.

Inspections

Prior to transporting passengers, a daily inspection shall be conducted by a competent person under the supervision of manager of operators of ropeway. As a minimum, the inspection shall consist of the following:

i. Inspect visually each terminal, station, and the entire length of the ropeway, lift or tow, including grips, hangers and carriers;
ii. Note the position of tension carriages and counterweights and ensure that the tensioning system is free to move in both directions;
iii. Test the operation of all manual and automatic switches in terminals, stations, and loading and unloading areas as per the manufacturer's specifications;
iv. Test the operation of main drive and all braking systems;
v. Test the operation of communication systems;
vi. Ropeways and lifts having emergency power units shall have the emergency engine checked during this inspection and operated at least once weekly;
vii. Note the general condition of the hauling rope including splices;
viii. Commissioning inspection including load test runs;
ix. Formal pre-season inspection;

x. Fairly and periodic maintenance inspections;
xi. Annual inspection (or at change of ownership);
xii. Periodic major inspection of critical components; and
xiii. Designer and manufacturer stipulated inspections and ancillary equipment inspections.

Ropeway Operator

The position of ropeway operator shall be such that he shall have the best possible view of the route and the controls and communicating devices shall be within his reach. The control

panel must have following indicator:

- Speed indicator,
- Indicator for the vehicle position along the line, and
- Fault indicator.

The driving gear shall be provided with an emergency motor fed by auxiliary power or Internal Combustion engine which can ensure a rescue operation as needed even when there is something wrong with the main motor or even in case of power failure.

However, installations having length less than 200m winching device may be provided. Working of the main motor shall be stopped automatically when any brake is on or if any safety device operates. Two different friction brakes called 'service brake' and the other 'emergency brake' shall be used in case of electric motor drive to cause both the normal stopping and emergency one. Each of such brakes shall be able to ensure the safe stopping of the installation's motion under most unfavorable conditions of loading. In any case, the nominal average deceleration shall not exceed 0.5 m/s^2 A suitable automatic device which prevents the reverse motion of the system in normal service shall be installed.

Communications

All stations shall be connected to each other by mobile telephone. Minimum one station shall be linked up with the public network. Communication facilities (telephone or wireless) shall be provided in the vehicle for communication with the driving station or with the second vehicle.

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

The following testing must be carried out:

Load testing at 5 yearly intervals or at change of critical load bearing components; non-destructive testing; and destructive testing (ropes).

All non-destructive testing must be carried out by a suitably experienced person and in accordance with relevant Indian Standards.

Procedures must be developed (and regularly audited) for

- Daily start-up, running and shut-down;
- Daily and periodic maintenance; and environmental conditions

Maintenance program for aerial ropeway towers

Particular attention must be given to towers. In these circumstances, the employer must make sure the maintenance program includes regular tests (e.g. torque tests or visual inspection) to check for fatigue or corrosion of the anchor bolts on tower.

Consideration must also be given to whether the towers and anchorage system have been subject to any random vibration due to movement of the haul rope and carrier grips over sheave assemblies and other factors that may have an impact on the effectiveness of anchor bolts such as:

- Whether a continuous uphill load imposed by the subtended angle of the haul rope on any vertical tower might lead to excessive fluctuating loads on the anchor bolts; or
- Whether tower base plates that are not fitted directly to the concrete footing have incorporated expanding grout between the tower base plate and the upper surface of the concrete footing to allow a continuous tension load on the anchor bolts to be maintained.

As well, towers that have bracing tubes around anchor bolts connected to the main tower tube by a gusset should be subject to detailed investigation for water retention and resultant corrosion. In addition to the tower maintenance procedures must address the major components and systems. The following is a brief overview:

- Chair, Hanger and Rope Grip assembly,
- Ropes,
- Haul Rope,
- Counterweight Tension Rope,
- Guy Ropes or Stays,
- Rope Tensioning Equipment,
- Communication and safety systems including emergency stop,
- Drives,
- Main Drive,
- Standby Drive,
- Rescue Drive,
- Integrity of power source for all drives,
- Sheave assemblies and rope guiding equipment,
- Line sheave assemblies, sheave bearings and liners,
- Alignment,
- Bull wheels,
- Drive and return sheaves, bearings and liners,
- Rope guiding equipment,
- Alignment,
- Brakes,
- Service Brake,
- Emergency Brake,
- Anti-rollback systems,
- Backstops and anti-rollback brakes,
- Loading and unloading stations and equipment,
- Safety Gates,
- Firefighting equipment,
- Inspection and testing requirements in accordance with Australian Standards,
- Electrical systems and equipment,
- Earthing systems,

- Control and monitoring devices,
- Emergency evacuation – procedures and equipment, and
- Corrosion protection

Termination of daily operations

Procedures shall be established for terminating daily operations to ensure that passengers shall not be left on the ropeway after it has been shut down.

7.11 CONTROL AND SAFETY OF PASSENGERS

The operating agency shall have specific plan for marshalling passengers for safe loading and unloading. The ropeway manager shall draw up special instructions necessary to be observed by staff to ensure the safety of children riding the ropeway, and shall ensure that such instructions are implemented and enforced by the staff. Loading attendants are to ensure that passengers do not embark on chairs, or in cars or cabins, with equipment which will in any way be a hazard to the safety of themselves or other passengers.

Appropriate signs shall be posted where they may be easily read by all persons using the ropeway. Some commonly used wording, suggested for use in connection with passenger ropeways signage is as follows:

- If not familiar with use of lift, ask attendant for instructions
- Prepare to unload *(Not less than 15 m ahead of the unloading area)* Keep ski tips up *(Ahead of any points where skis may come into contact with a platform)*
- Unload here
- Do not swing or bounce chairs
- Stay in track
- No loose clothing or long hair exposed (At loading area)
- Remove pole straps from wrists (At loading area)

The ropeway management should ensure that adequate provisions, such as pictograms, are made for passengers, who do not read or speak Hindi or English, to be able to use the ropeway correctly and safely. Any additional signs which may be required to ensure the safe operation of the ropeway shall be posted to the satisfaction of a competent person.

Markers

Where guyed towers are used and guys meet the ground within ski-runs, the guys shall be marked for visibility, preferably with boards painted with black and yellow stripes.

First aid at Ropeway

There shall be ready access to first-aid supplies and equipment, and provision shall be made to render first aid in the event of persons being injured on the ropeway.

7.12 SAFETY MANAGEMENT PLANS

Under a safety management plan, the licensed contractor will be required, as per terms and condition of licensing, to submit the names of the people and their corresponding qualifications that will provide service and maintain the installed passenger ropeway equipment. Contractors will need to have this safety management plan in place at each area where passenger ropeways or passenger conveyors are operating.

Safety Manager

The operator of ropeway will have Safety Authenticity. Safety Authority appoints the local safety manager, who is given the authority to perform the following duties:

- Provide technical support and expertise to Safety Officers;
- Evaluate industry training programs and the qualifications of those who train attendants and operators;
- Provide correct interpretation of the *Safety Standards Act* and regulations;
- Issue, suspend, or revoke a contractor's license as necessary;
- Review safety management plans;
- Issue directives, discipline orders, monetary penalties, and safety orders; and
- Review a Safety Officer's decision upon a client's request.

Other responsibilities of the Safety Manager include recommending regulatory changes, providing input on the operational functions of the program, advising on risk management systems, and undertaking incident investigations.

Safety Officers

Safety Officers are at the forefront when dealing with owners and licensed contractors. They are an integral part of the program and report on wherever safety is compromised. Some of their responsibilities are as follows:

- Issue permits;
- Answer inquiries;
- Conduct safety inspections;
- Investigate, document, and follow up on incidents;
- Promote public and worker safety awareness;
- Educate and provide technical information to industry owners and contractors on changing technology, codes, and standards;
- Develop and deliver training, seminars and briefings;
- Grant variances;
- Provide recommendations to the Safety Manager;
- Conduct compliance monitoring and audits; and
- Assess the need for changes to the regulations.

During a periodic inspection, a Safety Officer may inspect towers, sheave assemblies, brakes and braking functions and the operation of main drives, auxiliary drives, and evacuation drives where applicable.

Procedures for Strange Occurrences

The management shall prepare, and put in the control booth for which the procedures to be followed in case of unusual occurrences, such as:

- Roll back;
- Over speed;
- Counterweight limits reached;
- Tower development switch tripped;
- Communication system failure;
- Fire; and
- Earthquake.

7.13 ELECTRICAL PROTECTION

All overhead electrical power transmission wiring shall be so protected that, in case of collapse or breakage of the power line, it will not come into contact with chairs, cars, cables, or passengers.

Investigating Incidents

A Safety Officer investigates serious incidents as soon as they are brought to the attention of the Safety Authority. Under the Industrial Safety Act, an incident is the occurrence of a death, personal injury, or damage to property, or the risk of personal injury or damage to property. An incident is the result of regulated work or the testing, use or operation of a passenger ropeway. The levels of an incident, personal injury and damage to property can range from serious to minor.

Incidents may be caused by mechanical failure, passenger error, abnormal weather or operational error. Whatever the case may be, the Safety Manager will consider what measures may be taken to prevent similar incidents from occurring and what will be necessary to get the equipment back into operation.

7.14 Safety Certification

The safety certification shall be issued under the provisions of Himachal Ropeway Act, and in accordance with the requirement stipulated in IS 5229 (latest revision).

7.15 FINDINGS OF RISK ASSESSMENT AND MITIGATION MEASURES

7.15.1 Hazard Identification : Operation Phase

Hazard of passenger stampede ;
With reference to ropeway passenger capacity of 1500 PPH heavy rush and cross traffic toward both direction will be noticed. In case of any emergency alarm /Announcement passenger's panic situation may cause stampede at entry and exit gates of Gulaba and Marhi stations During emergency situation.

Hazard of Missing /Lost in snow :
During extended winter season passengers of Gulaba may miss or slipped down on snow bound Beas river as Gulaba terminal is situated near deep valley.

Hazard of Accidental Injuries :
I) Altitude sickness may occurs at Marhi and Rohtang upper terminal, when Ropeway passenger cannot get enough oxygen from the air at high altitudes.
II) Frostbite, medically named cryopathy, sets in when the body is exposed to temperatures of, or below, 0 deg C / 32 deg F. The effects can be seen most commonly in the fingers, toes, chin, cheeks, nose and earlobes, but it is actually the skin tissue and blood vessels of these extremities which are damaged.
III) Chances of exposure to Hypothermia at Marhi and Rohtang locations : Hypothermia is reduced body temperature that happens when a body dissipates more heat than it absorbs. In humans, it is defined as a body core temperature below 35.0 °C (95.0 °F). Symptoms depend on the temperature. It classically occurs from exposure to extreme cold.
IV) Severe Acute Mountain Sickness (AMS) can also take the form of High Altitude Pulmonary Edema (HAPE.) This is where excess fluid develops in the lungs, either in the lung tissue itself or in the space normally used for gas exchange. This means individuals are unable to perform gas exchange properly and so person cannot get enough oxygen to function normally. It is caused, again, by poor acclimatization and is often more common in males, although it is not clear whether this is behaviour related or due to genetic susceptibility. HAPE can occur without the traditional signs of AMS. Indications of HAPE include:

- Difficulty in walking or inability to keep up
- A tight-feeling chest
- Congestion
- A chesty cough, possibly accompanied first by a clear phlegm and later by blood.
- Extreme fatigue/weakness
- Gurgling sound whilst breathing. If you place an ear to the victim's chest, you may hear crackling or gurgling noises.
- Poor judgment
- Breathlessness during rest
- Rapid heart rate (90 to 100 bpm at rest)
- Blue/grey lips or fingernails (cyanosis)
- Fever of up to 101.3° F/38.5° C
- Profuse perspiration
- All symptoms are worse at night
- Confusion ,Collapse even Coma

Mechanical Hazards
Three section of ropeway should work simultaneously. However, due to cable cars, ropes, big & heavy machineries, mechanical hazards can cause risks to people working in the area during construction phase and passengers who will travel through the ropeway in operation phase. Mechanical hazards are like drive / return sheave shaft failure / tension system failure, mount Assembly parts failure, rollback, slippage/fall of cabin, entanglement of cabin, swinging of cabin resulting in fall of passengers outside cabin, cabin derailment at station etc.

Noise Hazard

Construction Phase: During the construction phase, source of noise will be the construction activities & equipment's, vehicles for transportation of raw material and DG sets. Although, noise during this phase would be only for specific period of construction, Standard methods and machineries will be used. Also, noise barriers shall be installed around the construction area to suppress the noise.

Operation Phase: During operation phase, the source of noise will be operation of Ropeway, DG sets and transportation. Standard Ropeway machineries will be used & will be maintained timely. Proper maintenance of the ropeway will be done to ensure low or no noise and environmental impacts. DG sets will be bought with acoustic enclosures.

Bio Hazards

STP Plants are provided near all terminal stations. However, incase of flood situation in Kothi being near to nalla, collected untreated waste water may be released to Beas river

Fire and Explosion

I) Multistoried Car parking lot of 300 car and bus capacity at Kothi will be very high Fire Load and chances of accidental car fire cannot be ruled out .
ii) Requirement of Oils for all Terminals is very high, Thus 3 day inventory storage tank for DG is advisable at Kothi considering traffic jams and availibity of POL from Kullu.
iii) Electrical Fires : Since it is a ropeway project, fire can mainly cause due to electric spark in electrical room, fire in the surrounding forest area, fire in fuel storage places, etc.
iv) Proposed seat heating arrangement may cause Fire in cabins if combustible material such as solvents and alcohol accidentally leaked near seat heating system.

This cabin fire can cause suffocation due to harmful gases generation & panic in the minds of passenger.

Electrical Hazards

The ropeway will run on electricity & hence electrical current can pass through cable cars & wires due to inadequate insulation or accidently.

Sabotage

Antisocial activities such as IED and Bomb Plantation inside cabin or inside Ropeway terminals, War, crisis & terrorists can cause panic among public and staff.

Biological Hazards

Microorganisms (e.g., bacteria, viruses, fungi, molds) Diseases or illnesses can occur from biological sources: In many cases, the route of entry is cuts in the skin or breathing. Some diseases are minor infections; Bio Hazards may causes Lyme Disease – Histoplasma capsulatum fungus, Rabies Plant toxins, oils etc.

Figure 7.6: Impact of strong gusty wind, Risky during ropeway stuck-up due to Mechanical Failure

Ergonomic Hazards

Ergonomic hazards can cause painful and disabling injuries. These hazard caused by heavy, frequent, or awkward lifting, repetitive tasks, awkward grips, postures, using excessive force, overexertion, using wrong tools for the job or using tools improperly, using improperly maintained tools and hand-intensive work. Manual handling is common in construction work and is one of the most common causes of injury at work.

Strains and sprains is one of the most common injuries among construction workers. Low back pain, fatigue Ergonomic hazards can cause a lifetime of pain and disability such as Musculoskeletal Disorders (MSDs) .

Vertical Evacuation

Hazards during vertical Evacuation likely to happen in section III of Marhi to Rohtang. It is advisable to avoid vertical evacuation in high wind weather and in snow bound slippery area.

Figure 7.7: Use of a helicopter to evacuate/ rescued from a stalled cable ropeway cabin

7.15.1 Natural Hazards

Avalanche

Hazards from Avalanches Likely threats to proposed ropeway from Kothi to Rohatang. In section III, Rani Nalla avalanche is big threat to ropeway, however safe location is identified for construction of upper Rohatang Terminal. There are three types of snow avalanche zones :

• Red Zone - The most dangerous zone where snow avalanches are most frequent and they have an impact pressure of more than 3 tonnes per square metre. In Gulaba and Marhi (Sec-II) and Marhi and Rohtang (Sec-III), many places like Rani Nalla etc is part of Red Zone
• Blue Zone - Where the avalanche force is less than 3 tonnes per square metre and where living and other activities may be permitted with connection of safe design but such areas may have to be vacated on warning.
• Yellow Zone - Where snow avalanche occur only occasionally.

The direction of the flat faces is the exposure of the cell to be treated for assessment of Avalanche zone. Consequently, the lower the value of slope, the flatter the earth's surface is given; the higher the value of the slope, likelihood of Avalanches threat is more. **Table 7.3** describes the characteristics of slopes with respect to steepness of slopes for the assessment of natural hazards.

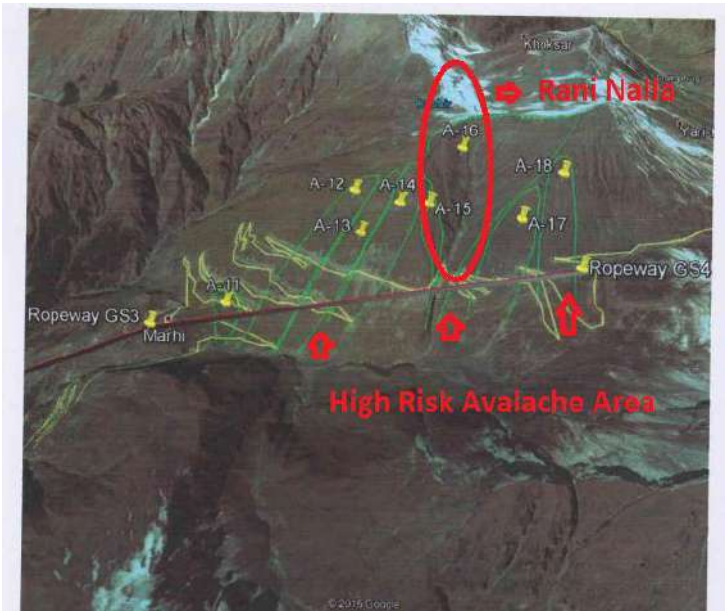
Table 7.3: Slopes And Characteristics Of Hazards

Sl No.	Types of Slopes	Steepness in degrees	Characteristics of Hazards
1	Sloping	6-30	Sloping hillsides, not dangerous
2	Steep	30-45	Landslides, talus, avalanche
3	Precipitous	45-60	Inaccessible avalanche slopes
4	Sheer	60-90	Inaccessible slopes

1. Avalanche site at Gulaba : Location is nearly 500m from ground station GS2 along Manali-Rohtang NH-21. It starts below highway and extends up to river bed. Occasional debris depth observed on the highway is 4-4.5m and creates Moderate Risk.
2. Avalanche site Shikari-Khol : Location next to avalanche site along Manali-Rohtane NH-21. It starts below highway up to river bed. Frequent debris depth is observed on the highway of 4-7m which creates High Risk.
3. Avalanche at Rahla : Location next to avalanche site along Manali-Rohtang NH-21. Debris depth of 4-8 m on the highway creates High Risk.
4. Avalanche at Rahla II : Debris depth of 4-7 m on the highway creates High Risk.

The third section of ropeway alignment : Marhi to Rohtang Top passes over at least eight High Risk avalanche areas. **Figure 7.8** depicts one such high risk zone.

Figure 7.8: High Risk Zone



The ropeway station at Marhi is located on forest land, part of which is being utilized for plantation of medicinal plan. The Upper Terminal Location is comparatively safe with reference to Avalanche threat. Risk due to chilled wind is identified at locations as given in **Table 7.4.**

Table 7.4: Risk Along The Ropeway Corridor Due To Natural Hazards

Sl No.	Location	Reason of Risk	Risk Zone
1	Avolanche site A_II (Marhi_I)	Chilled wind, Avalanche	High Risk
2	Marhi II Formationrone.4o40-3950m	Chilled wind, Avalanche	High Risk
3	Shela-Shar I	Chilled wind, Avalanche	High Risk
4	Shela-Shar II	Chilled wind, Avalanche	High Risk
5	Rani Nallah	Chilled wind, Avalanche, Debris depth 9-16m on highway, sudden weather changes	Very High Risk
6	Rohtang I	Chilled wind, Debris depth 4.5 8 m on highway, sudden weather changes	High Risk
7	Rohtang II	Chilled wind, Debris depth 4.5 8 m on highway, sudden weather changes	High Risk

Landslides

Landslides are simply defined as the mass movement of rock, debris or earth down a slope and have come to include a broad range of motions whereby falling, sliding and flowing under the influence of gravity dislodges earth material. They often take place in conjunction with earthquakes and floods. Cloud burst or prolonged rainfall causing heavy block the water flow leads to landslides. The formation of river blocks can cause havoc to the settlements downstream on its bursting. In the hilly terrain of India including the Himalayas, landslides have been a major and widely spread natural disaster the often strike life and property and occupy a position of major concern. Locations of likely landslides are between Gulaba to Marhi Ropeway alignment ROW. Landslide may cause major hurdle during road evacuation of stuck-up passenger from Marhi and at above level stuck-up tourists.

Cyclone & Heavy wind

Assessing the parameters to secure stability of the line is ensured in strong wind conditions which vary from time to time in Pirpanjal Range of Himalaya. Prime consideration is the effect of very strong or sudden winds. Wind may be considered to act in any direction, including upwards. As a general rule the pressure of the wind pressure, Pw (kg/m2), on the ropeway and all exposed equipment may be calculated by the empirical formula Vw 2 /16 (kg/m2) where Vw is the maximum expected wind velocity in m/s in the vicinity of the line. This empirical formula may be adjusted proportionately by any variation in temperature or density of the air from the nominal, value of 15°C and 1.25 kg/m3. However, even without any adjustment, this value is considered appropriate.

Hazards of "Crossed cables"

Crossed cables means, when the haulage cable crosses the cable on which the cabins are suspended. This may happen in the event of a sudden stop during the trip or strong gusty winds. A procedure to uncross the cables exists which was immediately put into operation as soon as the problem was discovered.

Flood

Lower Terminal station at Kothi situated near Nalla may leads to threat of flood during cloud burst /heavy rain. Flood water may rush into Terminal and Car Parking lot. As entry and exist access to car parking lot near LTP is limited, during emergency car stampede cannot be ruled out.

Figure 7.9: Lower Terminal at Kothi Flood Hazard and Fire Hazard

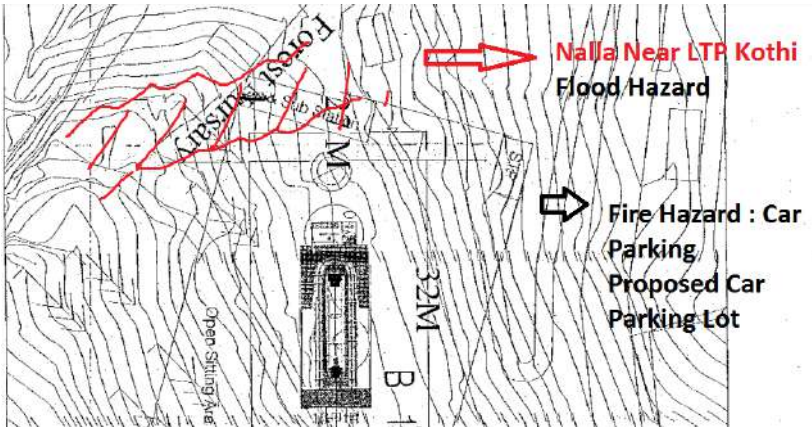


Figure 7.10: Intermediate Terminal Station Gulaba Hazard Identification

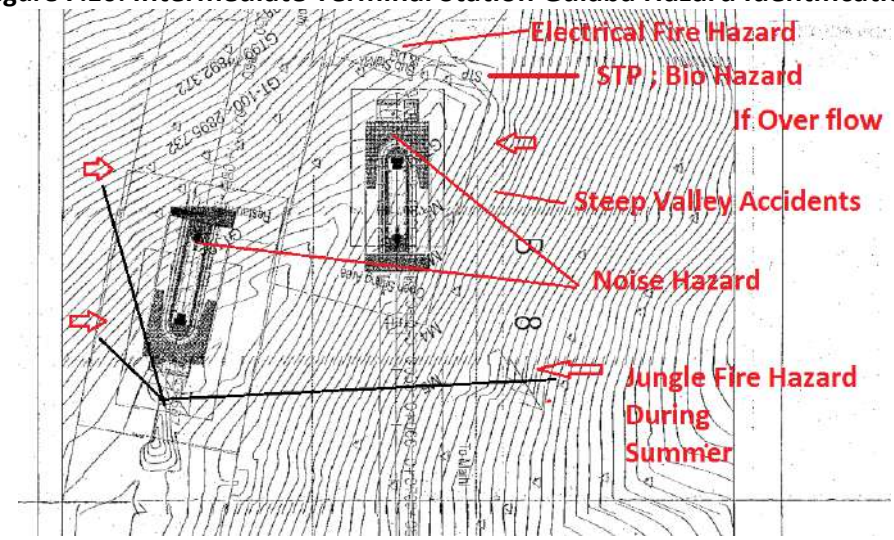
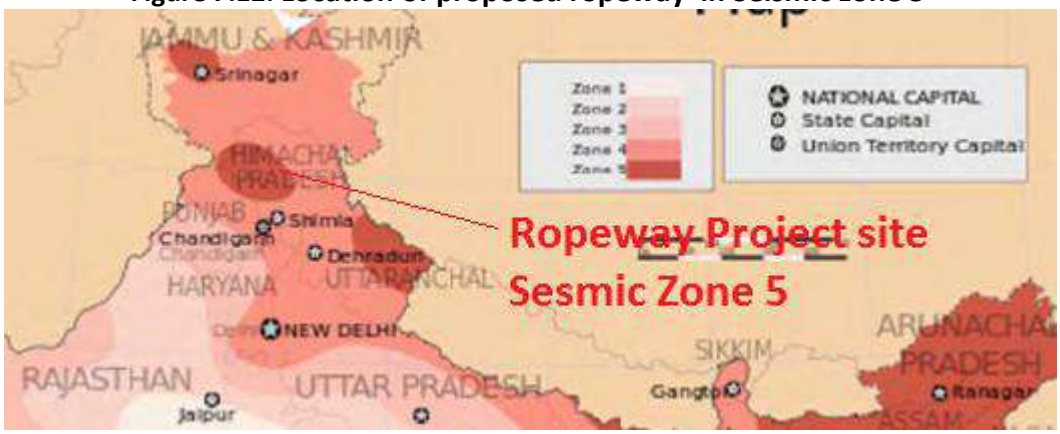


Figure 7.11: Location of proposed Lower Terminal at Kothi Flood/Land slide Hazards; near Nalla passing near LTP L

Earthquake (Seismicity)

As per the figure of the Geo-tech report, the project site is located in seismic zone V which indicates high damage risk zone.

Figure 7.12: Location of proposed ropeway in Seismic zone 5



Relevant code and standards will be utilized for earthquake resistance structures for Towers, Terminal stations, Car parking and STP plants considering factor of safety.

Road Accident &Traffic Jam Manali to Rohtang by Road

Traffic conjunction may cause delay during emergency. Fire Tender, Ambulance may stuck up in traffic. Risk assessment of the proposed ropeway corridor is summarised in **Table 7.5**. It describes the nature of hazards, stakeholders who might be affected, nature of risks, control measures, corrective actions and rating to the risk.

TABLE 7.5
HAZARDS, MITIGATION MEASURES AND RATING OF RISK

What are the hazards?	Who might be harmed?	What are the risks	Are the following control measures in place to eliminate or reduce the risks?	Corrective actions required	Risk Matrix	Risk Rating
Mechanical Hazards : Failure of a rope or drive .	Passengers, Tourists and MRPL employees	If windy situation cabin will swing high so as to cause accidental facture/ injuries Panic in passengers may have Psychological pressure leading to Rise in Blood pressure	Ensure that ropes and drives are of sound construction Regular Maintenance	Ropes should have a minimum factor of safety commensurate with the values specified in the latest Standards. Take account of any abnormal stresses or fatigue to which a rope may be subjected	8	LOW
Collapse or failure of any part of the installation, eg tower collapse	Tourist/staff MRPL Workman	Risk of Life Fractures/injuries Fetal accidents	Emergency stops, CCTV Watch & line censor and components exercised throughout ropeway system	Special Wind, cyclone, Earthquake Resistant foundations and structures of rope support towers, engine house stations, other buildings, ropes, sheaves, drive and rope tension units, brakes, cars and grips. Specific safety measures should be considered.	20	High
Impact or entanglement between cars or cars and structures;	Passenger and MRPL Employe	Serious Injury	careful consideration to ensure that clearances are sufficient and to avoid the risk of impact or entanglement with	advisable to take account of wind and other possible adverse environmental conditions (floods, ice. avalanches, lightning etc) and means of rescue in emergency situations.	12	Moderate

What are the hazards?	Who might be harmed?	What are the risks	Are the following control measures in place to eliminate or reduce the risks?	Corrective actions required	Risk Matrix	Risk Rating
	e		obstructions or part of the ropeway			
Passengers falling from cabin or coming into contact with cabin, moving parts of machinery or the structure while boarding/de-boarding	Passenger Employee	Fracture. Head Injury. Body part nip between hard surface	Cabin Auto Door locking system and moving part fencing	Predictive Maintenance Safety Communication Fencing Cabin Marshal	9	Moderate
Unsafe operation during boarding and alighting at stations, including uncontrolled crowds;	Passengers	Fall down Hand injury Body apart caught while auto door closing and Dragged with cabin	Provided walkways, ramps and access routes Provided secure foothold under all foreseeable weather conditions. Secured fencing should be provided wherever possible at any place where a person might fall 2 m or more.	Safe and suitable means of access to and from cars is needed for normal operation and in the event of an emergency.Safe access to other parts of the structure is required for inspection, maintenance and operational purposes. Controlled entry of passengers by MRPL staff	8	Low
Uncontrolled movement of cabin caused by high winds;	Passengers	Panic stage Nervousness Rise of Blood Pressure, Serious Injuries and even	Safety Instruction announcement from control room Provisions of hand holds/belts	Regular inspection of cabin Rope way slowdown speed Do and Don't Instruction displayed Wind pressure for ropeway design shall be as per CEN code. During high	18	High

What are the hazards?	Who might be harmed?	What are the risks	Are the following control measures in place to eliminate or reduce the risks?	Corrective actions required	Risk Matrix	Risk Rating
		Fracture in case of very high wind Likely Cross cable hazard		speed, ropeway will have closed cabin		
Reckless behavior by passengers, including dropping or throwing objects out of cars:	Public/Local /MRPL Employee	Grass Fire in ROW/ROU Ignition Head injury	Dos & Don't Instruction CCTV Watch & Ward	Penalty for Misbehavior	6	Low
Passengers being stranded in cars following loss of power or other emergency situations	Passenger	Panic, Mountain Sickness and Height Phobia leads to Vomiting	Correct positive announcement from control room Info about Relief Operation	Provide two way communication System to clarify Situation	8	Low
Maintenance related activities;	MRPL Workman Staff	Unfamiliar with the layout of the ropeway, they might be in a crowd, possibly intendance work, might need to get to areas where normal access is difficult and be exposed to diving mechanisms or	Sop/plan/a section Drawings Details to be provided	Frequent site visit as per Maintenance plan and typical location By staff & workman	4	low

What are the hazards?	Who might be harmed?	What are the risks	Are the following control measures in place to eliminate or reduce the risks?	Corrective actions required	Risk Matrix	Risk Rating
		other dangerous parts.				
Exposure to the elements, eg hypothermia;	Passengers, MRPL staff and workman	Slow,shallow breathing. Confusion and memory loss. Drowsiness or exhaustion, Slurred or mumbled speech Insevere hypothermia, a person may be unconscious without obvious signs of breathing or a pulse	Remove any wet clothes, hats, gloves, shoes, and socks. Protect the person against wind, drafts, and further heat loss with warm, dry clothes and blankets.	Move gently to a warm, dry shelter as soon as possible. Begin re-warming the person with extra clothing. Use warm blankets. Other helpful items for warming are: an electric blanket to the torso area and hot packs and heating pad on the torso, armpits, neck, and groin;	12	Moderate
Electrical hazards, eg shock, burns.	Passengers, Staff & workman	Burn Injury Electrocution Fetal Accidents	Electrical safety at correct intervals and labeled with the date of the test. Any Electrical safety singes. Use of suitable PPA/PPE	Organize third party Electrical Safety audits	08	Low

7.15.2 Mitigation Measures

1. The failure of a rope or drive could have catastrophic results. It is therefore vital to ensure that ropes and drives are of sound construction, suitable for the purpose intended and well maintained. Ropes should have a minimum factor of safety commensurate with the values specified in the latest European Standards, or in their absence a minimum value of five for running ropes. This is required to take account of any abnormal stresses or fatigue to which a rope may be subjected.
2. Recommended dose of acetazolamide is usually 125mg or 250mg twice a day. Passenger should begin taking the medication one to two days before you start to ascend and continue to take it while ascending.
i) Medical Inspection Room with trained doctors and paramedical staff provided at Kothi, Gulab, Marhi and Rohatang Terminal. Relevant medicines, Oxygen and life saving medicines will be provided. Closed warm Restaurant Hall with heating system arrangement will protect passengers during heavy cold wind and ropeway maintenance/Repairs during operation.
ii) In case of acute High Altitude Pulmonary Edema victim will be shifted to lower terminal and Mission Hospital Manali by road.

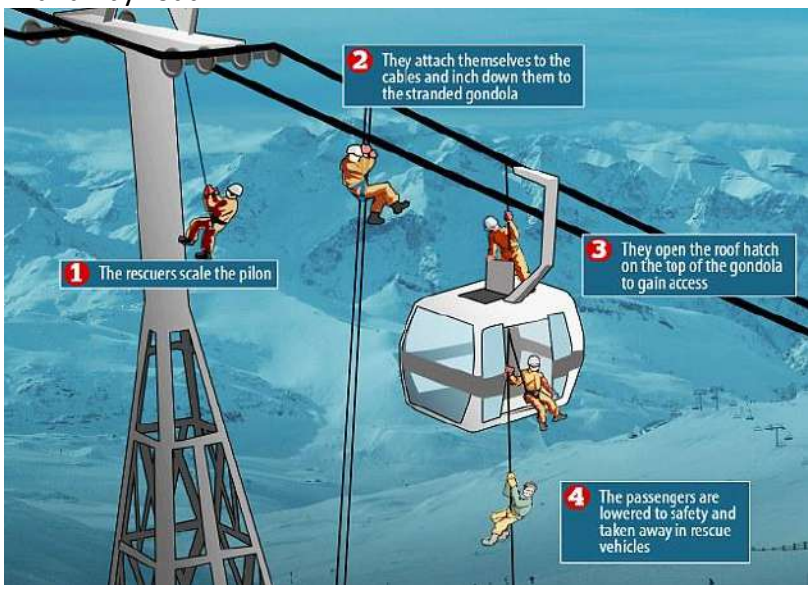


Figure 7.13 : Vertical Evacuation

iii) However, as traffic jams and narrow descending roads toward Manali may take long time may lead to fetal incident.
iv) It is recommended that such victim may be airlifted to Manali for saving precious life of passenger by Helicopter from Marhi or Gulaba terminal.
v) Considering High wind velocity at Rohtang pass and Marhi, stability and air lifting is risky and may cause accidents. Low windy safe area near or below Marhi Terminal to be identified for airlift evacuation is recommended.
vi) In future, it is recommended that agency for Aerial Evacuation by Helicopter to be arranged on payment basis.
vii) Passenger accountability and perfect token system to be introduced for Missing passengers at each Terminal.
viii) As Rohtang pass weather changes suddenly, it is harmful to old/ aged/handicapped passengers , sick & pregnant passenger, children and infants , Passenger must be informed via notice board /announcing /public address system.
x) Passengers self willingness /written Consent is advisable.

xi) Ropeway Entry based on Age limit and medical fitness from Marhi to Rohatang section

Mitigation Measures for Ropeway operations are described in Figure 9 and described in following paragraph.

Figure 7.14 : Use of Helicopter for tower erecting job –Risky work

1) Self-propelled emergency rescue vehicle should be introduced for safety of passengers and rescue them during emergency**.**
2) Introduced Hyperextension detection device and over-tension detection device for automatically detection and control of cable tension.
3) provide Cable detachment detection device to ensures cars entering the station will slow down in the event of cable detachment.
4)Introduced Emergency stop device: automatically stops the ropeway system in abnormal conditions.
5)Incomplete cable gripping detection device and incomplete cable detachment detection device: automatically detect and initiate rectification procedures in abnormal cable gripping conditions.
6) Car door open and close detection device: ensures car doors are automatically and securely opened and closed.
7) Car distance control device: adjusts distance between cars based on number of carts dispatched during operations.
8) Anemometer, speedometer, anti-lightning equipment, security communication equipment, etc to ensure the comfort and safety of all passengers.
9) Lightning rods and grounding grids to be installed at each tower and all towers are connected in parallel via lightning prevention wires to reduce grounding resistance to ensure cabin safety.
10) Fire Safety provisions : kothi Car parking building & all terminals to be provided Fire detection, alarm, address and sprinkler system.
11)Provision of DCP cylinder& two way communication system in cabin as seat heating arrangement provided in cabin.
12)Standard electrical safety and indicating devices shall be provided on ropeway. Special emphasis shall be paid to line de-ropement switches with independent control circuit to pin

point the defect shall be used. As the ropeway terrain is difficult, each tower and sensitive location will be provided with pan/tilt/zoom type wired cameras to monitor the line status before starting the plant each day. As the plant is located in remoteness and nearest town is far away, enough stock of such small electrical and safety items are required.

13)This ropeway in Section 3 Marhi to Rohatang pass is adventure ride, passenger traceability and accountability system at all terminals to be introduced.

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