RISK ASSESMENT

&

DISASTER MANAGEMENT PLAN FOR MUMBAI COASTAL ROAD PROJECT

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RISK ASSESMENT AND DISASTER MANAGEMENT PLAN

1.0 DISASTER MANAGEMENT PLAN

1.1 General

The Coastal Road Project planned by the Municipal Corporation of Greater Mumbai (MCGM) is a mega project which includes several types of construction viz. large scale reclamation in the sea along the Coastline, land filled roads, tunnels, road on stilits, Bridges in Sea and Interchanges. It is therefore, important to formulate a project specific Risk Assessment & Disaster Management Plan in order to be in a state of preparedness to respond in a strutured and systematic manner to the disasters when they occur, so that loss of human life is minimized and recovery is possible within a short time after the disaster.

1.2 Definition of Disaster

The UNISDR (2009) defines disaster as:

“A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.”

UNISDR considers disaster to be a result of the combination of many factors such as the exposure to hazards, the conditions of vulnerability that are present, and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injuries, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation.

The DM Act 2005 uses the following definition for disaster:

"Disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.”

Since the scale of the disruptions due to disaster is beyond the ability of the affected community or society to cope using it’s own resources, it is obvious that in order to have an effective Disaster Management Plan for the project – during construction phase and operational phase, an effective interface has to be maintained at all times by the project personnel during the Construction Phase (by Contractor/Supervision Consultants) and in operations phase, with the State Disaster Management Unit which includes the Disaster Management Unit of the MCGM. In other words, the Disaster Management Plan for the project must integrate with and complement the Disaster Management Plan of GoM/MCGM.

1.3 Scope

This document describes the provisions which have been kept in the project components viz. Tunnels, roads and Bridges, in order to mitigate the effects of Disaster and also for providing an early warning system to the concerned authority/personnel on occurrence of accidents/impending disaster. In addition, it also describes, in general, the measures and actions which should be incorporated in the Disaster Management Plan for the Project during Construction Phase of Tunnels and Roads & Bridges and during the Operations Phase. It is imperative that the DMP for the Construction and Operations phases should be finalized and amended as required, after due consultation with all the stakeholders and agencies involved in Disaster Management. The document also gives the Standard Operating Procedures (SOPs) to be followed during the Construction Phase. These SOPs are based on the provisions of MORT&H Specifications & IRC Special Publication, which are commonly used for the construction of Highway/Bridge & Tunnel Projects in India.

1.4 Types of Disasters/Hazards

Primarily disasters are triggered by natural hazards or human-induced, or result from a combination of both. In particular, human-induced factors can greatly aggravate the adverse impacts of a natural disaster. Even at a larger scale, globally, the UN Inter-Governmental Panel on Climate Change (IPCC) has shown that human-induced climate change has significantly increased both the frequency and intensity of extreme weather events. While heavy rains, cyclones, or earthquakes are all natural, the impacts may, and are usually, worsened by many factors related to human activity. The extensive industrialization and urbanization increases both the probability of human-induced disasters, and the extent of potential damage to life and property from both natural and human-induced disasters. The human society is also vulnerable to Chemical, Biological, Radiological, and Nuclear (CBRN) disasters.

1.4.1 Natural Hazards

The widely accepted classification system used by the Disaster Information Management System of DesInventar classifies disasters arising from natural hazards into five major categories (DesInventar2016):

1) Geophysical: Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Hydro-meteorological factors are important contributors to some of these processes. Tsunamis are difficult to categorize; although they are triggered by undersea earthquakes, and other geological events, they are essentially an oceanic process that is manifested as a coastal water-related hazard.
2) Hydrological: Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up
3) Meteorological: Events caused by short-lived/small to meso-scale atmospheric processes (in the spectrum from minutes to days)
4) Climatological: Events caused by long-lived meso- to macro-scale processes (in the spectrum from intra-seasonal to multi-decadal climate variability)
5) Biological: Process or phenomenon of organic origin or conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

A brief description of these five major categories of the disasters arising from natural factors with the sub-categories is given in Table 1-3. The below classification is not a water tight one. In real life situations, many disasters are a combination of different types of disasters. In addition, secondary disasters may occur after a disaster has occurred.

Table 1-3: Categories of Natural Hazards

	Family	Main Event	Short Description/ Secondary Disaster
1		Earthquake/Mass movement of earth materials	• Landslide following earthquake; • Urban fires triggered by earthquakes; • Liquefaction - the transformation of (partially) water-saturated soil from a solid state to a liquid state caused by an earthquake • Mass movement of earth materials, usually down slopes • Surface displacement of earthen materials due to ground shaking triggered by earthquakes
		Tsunami	A series of waves (with long wavelengths when traveling across the deep ocean) that are generated by a displacement of massive amounts of water through underwater earthquakes, volcanic eruptions or landslides. Tsunami waves travel at very high speed across the ocean but as they begin to reach shallow water, they slow down and the wave grows steeper.
2	Hydrological	• Flood • Landslides • Wave Action	• Coastal Erosion - The temporary or permanent loss of sediments or landmass in coastal margins due to the action of waves, winds, tides, or anthropogenic activities • Coastal flood - Higher-than-normal water levels along the coast caused by tidal changes or thunderstorms that result in flooding, which can last from days to weeksFlash Flood Hydrological - Heavy or excessive rainfall in a short period of time that produce immediate runoff, creating flooding conditions within minutes or a few hours during or after the rainfall • Flood Hydrological - A general term for the overflow of water from a stream channel onto normally dry land in the floodplain (riverine flooding), higher-than normal levels along the coast and in lakes or reservoirs (coastal flooding) as well as ponding of water at or near the point where the rain fell (flash floods) • Wave Action: Wind-generated surface waves that can occur on the surface of any open body of water such as oceans, rivers and lakes, etc. The size of the wave depends on the strength of the wind and the travelled distance (fetch).
3	Meteorological	Hazard caused by short-lived, micro- to meso-scale extreme weather and atmospheric conditions that may last for minutes to days	• Cyclone, Storm Surge, Tornado, Convective Storm, Extratropical Storm, Wind Lightning, Heavy Rain

	Family	Main Event	Short Description/ Secondary Disaster
4	Climatological	Unusual, extreme weather conditions related to long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal (long-term) climate variability	• Extreme hot/cold conditions • Subsidence
5	Biological	Exposure to germs and toxic substances	• Epidemics: viral, bacterial, parasitic, fungal, or prion infections • Insect infestations

1.4.2 Human-Induced Disasters

The NPDM notes that rise in population, rapid urbanization and industrialization, development within high-risk zones, environmental degradation, and climate change aggravates the vulnerabilities to various kinds of disasters. Due to inadequate disaster preparedness, communities, and animals are at increased risk from many kinds of human-induced hazards arising from accidents (industrial, road, air, rail, on river or sea, building collapse, fires, mine flooding, oil spills, etc.). Chemical,

Biological, Radiological, and Nuclear (CBRN) hazards rank very high in among the human-induced risks. Terrorist activities and secondary incidents add to these risks and call for adequate preparedness and planning.

1.4.3 Levels of Disasters

The disaster management and its planning at various tiers must take into account the vulnerability of disaster-affected area, and the capacity of the authorities to deal with the situation. Using this approach, the High Power Committee on Disaster Management[5], in its report of 2001, categorized disaster situations into three 'levels': L1, L2, and L3. The period of normalcy, L0, should be utilized for disaster risk reduction.

Level-L1: The level of disaster that can be managed within the capabilities and resources at the District level. However, the state authorities will remain in readiness to provide assistance if needed.

Level-L2: This signifies the disaster situations that require assistance and active mobilization of resources at the state level and deployment of state level agencies for disaster management. The central agencies must remain vigilant for immediate deployment if required by the state.

Level-L3: This corresponds to a nearly catastrophic situation or a very large-scale disaster that overwhelms the State and District authorities.

The categorization of disaster situations into levels L0 to L3 finds no mention in DM Act 2005. Further, the DM Act does not have any provision for notifying any disaster as a 'national calamity' or a 'national disaster'.

2.0 Project Specific Provisions for Disaster Management Plan/provisions

2.1 Nodal Operation Control Rooms

Nodal Control Centers will be equipped with the latest Communication facilities and will be manned 24 x 7 during the Construction and Operations Phase. During the Construction Phase, these rooms will be manned by the Contractor's personnel along with the Supervisory staff of the MCGM Disaster Management Cell. These Control rooms will be established at the following locations:

a) Near Ch. 5 + 500 near Priyadarshini Park in South Portion of the Coastal Road

b) Near Ch. 10 + 500 near Ritumbara Interchange near Seven Bungalows in the North Portion of the Coastal Road

These Nodal Operation Control Rooms will maintain effective communication at all times with the various agencies listed in MCGM Disaster Management Plan viz.

- Police Commissionerate
- Traffic Police
- Municipal Corporation
- BEST
- MMRDA
- Home Guards and Civil Defence
- District Collectorates (City & Suburban)
- Indian Meterological Department (Regional Office)
- Railways (Central & Western)
- Fire Brigade
- MTNL
- Home Guards and Civil Defence
- Mobile Service Providers
- Hospitals
- Radio & TV Centre in Mumbai

2.2 Safety Measures during Construction of Tunnels

The Standard Operating Procedures/Safety practices to be followed during the construction of the Tunnels will be in accordance with the provisions of Clause 6.0 – Safety during Construction of Tunnels – IRC SP: 91 – 2010. A summary of provisions is given below. The Tunnel Contractor will formulate an elaborate Health & Safety Manual covering at least the following aspects before the commencement of construction activties.

Sl. No.	Description	Reference Clause No. of IRC SP 91 – 2010 – Tunnel Design
1	General – Background, Applicable Regulations, Project Safety Plan	6.1
2	Basic Aspects – Basic Philosophy, Personal Protective Equipment, Signage, Access Control Systems, Safety Systems	6.2
3	Drilling & Blasting – Drilling Operations, Blasting Operations, Inspection after Blasting, Misfires, Scaling & Mucking, Installation of Supports,	6.3
4	Ventilation & Noise Protection,	6.4
5	Lighting	6.5
6	Communciation System – Warning Signs & Notice Boards, Telephone Systems, CCTVSystem,	6.6
7	Protection against Fire – General, Fire System, Electrical Installations,	6.7
8	Housekeeping – General, Traffic Control, Pipes & Cables, Water Control	6.8
9	Emergency Management System	6.9

2.3 Supervisory Control & Data Acquisition (SCADA) Control Rooms for Tunnels (Operations Phase)

The tunnel monitoring systems viz. Fire Detection & Fire Fighting System, Ventilation System, Video Camera Control System, Emergency Communication System, Carbon Monoxide Detection System etc. will be housed in the Control Rooms for Tunnels. **These Control Rooms will be located at the Entry/Exit of the Tunnels and will be manned 24 x 7 by the O & M staff**. Communication links will be established between these Control Rooms and all the agencies listed in 2.1 above as well as with the Nodal Control Rooms.

The Tunnel Control Rooms with SCADA will play a vital role in ensuring safe operations in the Tunnel during the Operations Phase. The various provisions to be kept in the instrumentation are described in detail later in the manual.

2.4 Standard Operating Procedures to be followed during construction of Coastal Road

Standard Operating Procedures (SOPs) as stipulated in MORT&H Specifications – Revision 5, a document which is largely used in India for construction of Highways, shall be used during the Construction Phase. These also include precautions to be taken for safeguaring the environment. A summary of provisions is given below:

Sl. No.	Description	Reference Clause No. of MORT&H Specification
1	Borrow Pits for Embankment Construction	111.2
2	Quarry Operations	111.3
3	Control of Soil Erosion, Sedimentation & Water Pollution	111.4
4	Pollution from Plants and Batching Plants	111.5
5	Substances hazardous to health	111.6
6	Use of Nuclear Gauges	111.7
7	Environment Protection	111.8
8	Occupational Health and Safety of the Workforce	111.9
9	Control & Disposal of Waste	111.10
10	Transport of hazardous materials	111.11
11	Emergency Response	111.12

It is expected that the Contractor will prepare an exhaustive Health & Safety manual before commencement of Construction activities and implement the same rigourously.

2.5 Highway Traffic Management System (HTMS) during Operations Phase

Highway Traffic Management System will control the traffic monitoring and movements on the Coastal Road. The following outdoor units will be installed as a part of HTMS:

a) Emergency Call Boxes

b) Variable Message Signs

c) Meteorological Data Systems

d) Close Circuit TV Camera System

e) Traffic Counting, & classification and transmission system

Indoor units will comprise of the following:

1) Large Display board with Central Computer and Network monitoring system

2) CCTV System

3) Uninterupted Power Supply

The system shall meet the following objectives:

- Smooth and uninterupted Traffic flow
- Enhanced Road Safety
- Realtime information and guidance to road users
- Round the clock emergency assistance
- Alerts for abnormal road and weather conditions
- Reduced journey time and reduced driving fatigue

3.0 Approach to Disaster Management Plan

Environmental risks are inherent in design and operation of a complex project. Any major failure in the system could lead to a disaster resulting in loss of human life, loss to property and damage to ecology. Fig 1 depicts the type, causes, phases and categories of disaster. Growing concern has resulted Risk Assessment as a mandatory requirement during project reviews of MOEF.

Risk involves the occurrence or potential occurrence of some accidents consisting of an event or sequence of events. The conceptual activities involved in risk analysis studies are depicted in Fig. 2.

Table 1 present a flow chart for hazard study and risk analysis for any developmental activity. The sub tasks of the various phases involved in risk analysis are:

Maximum Credible Accident (MCA) analysis, Hazard Analysis, Assessment and Evaluation, Disaster Management Plan (DMP) and Emergency Preparedness Plan (EPP).

3.1 Maximum Credible Accident (MCA) Analysis

The word MCA stands for Maximum Credible Accident or in other words, an accident with a maximum damage distance, which believed to be probable. MCA analysis does not include quantification of the probability of occurrences of an accident. In practice the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgment and expertise in the field of risk analysis especially in accident analysis.

3.2 Hazard Analysis, Assessment and Evaluation

Less and more hazard prone sections of each unit are decided based on the FEI, TI and inventory analysis. Safety of less hazard prone section is studied using check list approach while detailed Hazard and Operability (HAZOP) studies is carried out for most hazardous sections.

The purpose of HAZOP analysis is to detect any predictable undesired event in a process to achieve a systematic study of the operations carried out for each process step involved and also the way in which the various components involved interact. This exercise is particularly important in the case of process for which there is no or only limited actual operating experience.

The HAZOP studies indicate all possible events and their consequences. In multi component systems, it is important to analyze the possible mechanisms for failure and to perform probabilistic analysis for the expected rate of such failures. Fault Tree Analysis (FTA) is a technique by which many events that interact produce other events that can be related using simple logical relationships which permit a methodical building of a structure that represents the system. Majority of the primary events that could lead to the failure of a unit (known as top event) could be derived from HAZOP studies.

The application of Monte Carlo Simulation consists in simulating the behaviour of components in accordance with the distribution of their lifetimes. This is done by generating random numbers having a uniform distribution over the interval and transforming the numbers into the desired distribution. This technique is also aimed at estimating top event probability taking into consideration multi event probabilities.

Applications of reliability engineering especially in the process control instrumentation are of recent origin. System performance can be evaluated by Assessment of Pathway reliability of each vulnerable process section. The quantitative estimation of pathway reliability helps in deciding reliability improvement strategies.

Whilst the quantitative assessment of reliability (or for that matter estimation of top event probability of an occurrence of an event using FTA and Monte Carlo Simulation) uses mathematical theories, it is hindered in practice by the lack of failure rate data from chemical-control instruments, equipments. This is of relevance, especially in the Indian context while adopting quantitative risk analysis approach. Generation of Indian Data base on failure rate date is therefore of vital significance.

3.3 Disaster Management Plan (DMP) and Emergency Preparedness Plan (EPP)

3.3.1 Disaster or Emergency and its Possibility

A disaster, and therefore an emergency, occurring as a result of a malfunction of the normal operating procedures or an intervention of an outside force such as a cyclone, flood or sabotage, that may affect several sections within it and/or may cause serious injuries, loss of lives, extensive damage to property or serious disruption outside the works.

Apart from earthquakes, cyclones, flood, arson and sabotage, serious, accidents may take place through explosion in Gas/Fuel Tankers, heavy leakage and subsequent fire in the oil storage tanks etc.

3.3.2 Objective of Disaster Management Plan

In order to be in a state of readiness to face any accident or disaster caused by the project operation, a Disaster Management Plan shall be be prepared. Such a plan ought to cover possible disaster, on and off-site emergency preparedness plan, establishment of Emergency Control Centers (ECC), location of emergency services, and duties of the officers/staff during emergency.

3.3.3 Basic Contents of DMP

Basically, the DMP will contain the following aspects:

i) Description of the Site
ii) On-site Emergency Plan
iii) Off-site Emergency Plan

The details of the project are briefly given below:

Project Details

The Coastal Road is divided in two parts as under:

a) **South Part – Princess Street – Malabar Hill (Tunnel) – Haji Ali – Baroda Palace – Worli end of Bandra Worli Sea Link**

Total Length – 9.98 Km

Length of the Twin Tube Tunnel **–** 3.452 Km

b) **North Part – Bandra end of Bandra Worli Sea Link – Carter Road – Seven Bunglows – Kandivli**

Total Length – 19.220 Km

Length of the Four Tube Tunnel **–** 5.77 Km

3.3.4 On-Site Emergency Plan

3.3.4.1 Objective and Contents

The objective is to combat emergency caused by an accident, the effects of which are confined to the Site involving only the people working on the project. This section essentially consists of an action plan which includes identification of key personnel; defined responsibilities of key personnel; designated ECCs and assembly points; declaration of emergency; all clear signal; actions to be taken by non-key Personnel during emergency.

3.3.4.2 Appointment of Key Persons and their Role

1. ***Site Controller (SC)***

   The General Manager (however called) or his nominated deputy will assume overall responsibility for the Site and its personnel.

2. **Incident Controller (IC)**

   A Production Manager or an Officer of similar rank will be nominated to act as the IC. Immediately on learning about an emergency, he will rush to the incident site and take overall charge and report to the SC.

3. ***Liaison Officer (LO)***

   Personnel/Administrative Manager or his nominated Officer of deputy rank will work as LO and will be stationed at the Nodal Control Centres during emergency to handle Police, Press and other enquiries.

4. ***Forward Area Controller (FAC)***

   Departmental Incharge of the concerned area will be the FAC to take care of the respective departments during emergency.

5. ***Team Leader (TL)***

   As number of specified activities may have to be carried out, for which specific teams have to be formulated and their roles or duties defined, each of them will be headed by a TL. The following teams are suggested:

   i) Task Force
   ii) Repair Team
   iii) Fire Fighting Team
   iv) Communication Team
   v) Security Team
   vi) Manpower Team
   vii) Safety Team
   viii) Transport Team
   ix) Medical Team

3.3.4.3 Emergency Control Centres (ECC)

Emergency Control Room is to be set up and marked on the site plan for the knowledge of all concerned. ECC is the focal point and it should be well connected with internal and external telephones and furnished with list of personnel and their addresses.

3.3.4.4 *Assembly Points*

Assembly points, the pre-determined safe places, where people will be directed after evaluation from the hazardous locality, have to be set up and marked on the site plan. Escape routes from assembly points have to be clearly defined and depicted.

3.3.4.5 *Alarms*

Suitable sirens will be provided at Site, which could be operated from the Nodal Control Rooms. The coding of the siren should be as per the standards and well circulated within the facility.

3.3.4.6 *Tie Ups for Aid with Institutions (Hospitals, Wards, Police Stations etc)*

It is essential to have mutual aid arrangements among the industries in the neighborhood which would help in the case of a major disaster.

3.3.4.7 *Training and Mock Drills*

Proper training of the key personnel and other non-key personnel, who will take part in case of an emergency, should be arranged. Mock drills will be performed to test the performance of the procedure laid.

4.0 Risk Matrix

	Family	Main Event	Short Description/ Secondary Disaster	Probablity of occurence	Proposed Actions
1	Geophysical	Earthquake/Mass movement of earth materials	• Landslide following earthquake; • Urban fires triggered by earthquakes; • Liquefaction - the transformation of (partially) water-saturated soil from a solid state to a liquid state caused by an earthquake • Mass movement of earth materials, usually down slopes • Surface displacement of earthen materials due to ground shaking triggered by earthquakes	Mumbai falls in Earthquake Zone III. Earthquakes have not been very frequent in Mumbai. In the past 400 years, major earthquakes have stuck only on 12 occassions, the last major earthquake occuring during 1966.	• Structures will be designed considering the seismic provisions as per Coadal provisions • Mock Drills. • Quick Evacuation of Site Workers and Staff • Contact to be maintained with nearest hospitals and Fire Stations for taking casulties for treatment and for rescue operations
1		Tsunami	A series of waves (with long wavelengths when traveling across the deep ocean) that are generated by a displacement of massive amounts of water through underwater earthquakes, volcanic eruptions or landslides. Tsunami waves travel at very high speed across the ocean but as they begin to reach shallow water, they slow down and the wave grows steeper.	There have been no past incidences of Tsunamis in Mumbai. As such, the risk of a Tsunami striking is considered to be low.	• Contact to be maintained with the regional office of IMD • Early warnings to the project workers/staff to be given, when applicable. • Quick evacuation of Site Workers and staff
2	Hydrological	• Flood • Landslides • Wave Action	• Coastal Erosion - The temporary or permanent loss of sediments or landmass in coastal margins due to the action of waves, winds, tides, or anthropogenic activities • Coastal flood - Higher-than-normal water levels along the coast caused by tidal changes or thunderstorms that result in flooding, which can last from days to weeksFlash Flood Hydrological - Heavy or excessive rainfall in a short period of time that produce immediate runoff, creating flooding conditions within minutes or a few hours during or after the rainfall • Flood Hydrological - A general term for the overflow of water from a stream channel onto normally dry land in the floodplain (riverine flooding), higher-than normal levels along the coast and in lakes or reservoirs (coastal flooding) as well as ponding of water at or near the point where the rain fell (flash floods) • Wave Action: Wind-generated surface waves that can occur on the surface of any open body of water such as oceans, rivers and lakes, etc. The size of the wave depends on the strength of the wind and the travelled distance (fetch).	**Coastal Erosion** The probablity of Coastal erosion occuring due to the Coastal Road construction is low. In fact, the Sea wall construction will offer protection against shore erosion. **Flooding** The Coastal Road level will generally, be higher than that of the existing road along the coast. As such, the probablity of flooding of Coastal Road is perceived to be low. The alignment does not pass through the chronic Flooding spots. Infact, the Coastal Road will offer a good and safe evacuation pasage for the public, in general. **Landslides** There is low probablity of landslides getting triggered due to earthquakes or floods.	• Contact to be maintained with the regional office of IMD • Early warnings to the project workers/staff to be given, when applicable. • Quick evacuation of Site Workers and staff
3	Meteorological	Hazard caused by short-lived, micro- to meso-scale extreme weather and atmospheric conditions that may last for minutes to days	• Cyclone, Storm Surge, Tornado, Convective Storm, Extratropical Storm, Wind Lightning, Heavy Rain	The coastline along the Arabian Sea is prone to Cyclones.	• Contact to be maintained with the regional office of IMD • Early warnings to the project workers/staff to be given, when applicable. • Quick evacuation of Site Workers and staff

	Family	Main Event	Short Description/ Secondary Disaster	Probablity of occurence	Proposed Actions
4	Climatological	Unusual, extreme weather conditions related to long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal (long-term) climate variability	• Extreme hot/cold conditions • Subsidence	Low Probablity	
5	Biological	Exposure to germs and toxic substances	• Epidemics: viral, bacterial, parasitic, fungal, or prion infections • Insect infestations	Low proablity	• Proper hygene to be maintained in the Worker's Camps, Canteens and Work areas. • Close co-ordination to be maintained with the City hospitals and Health Authorities.
6	**During Construction**	**Accidents**	• Accidents during construction of Road and Bridges/reclamation	Medium	• Formulation of Safety Policy and strict implementation of the same during construction phase. • Provision of First Aid at worksites • Arrangements with nearest hospitals for emergency treatment in case of accidents • Provision of Ambulances at the worksite.

4.1 AN APPROACH TO RISK ASSESSMENT

PHASE I: MCA ANALYSIS

- Process Information Study
- Study of Process Engineering Details
- Detailed Study of Plot Plan/Layout
- Hazard Identification through
- Inventory
- Effects Calculations
-

PHASE II: HAZARD ANALYSIS, ASSESSMENT AND EVALUATION

- Checklist approach for less hazard prone areas/sections
- HAZOP Studies
- Failure Frequency Analysis
- Data Collection
- Pathway Reliability Approach
- Protective System Hazard Analysis
- Evaluation of Hazards.

PHASE III: DISASTER MANAGEMENT PLAN (DMP)

- Suggest Preventive and Corrective Measure

PHASE IV: EMERGENCY PREPAREDENESS PLAN (EPP)

- Study of Existing EPP
- Emergency Preparedness
- Onsite

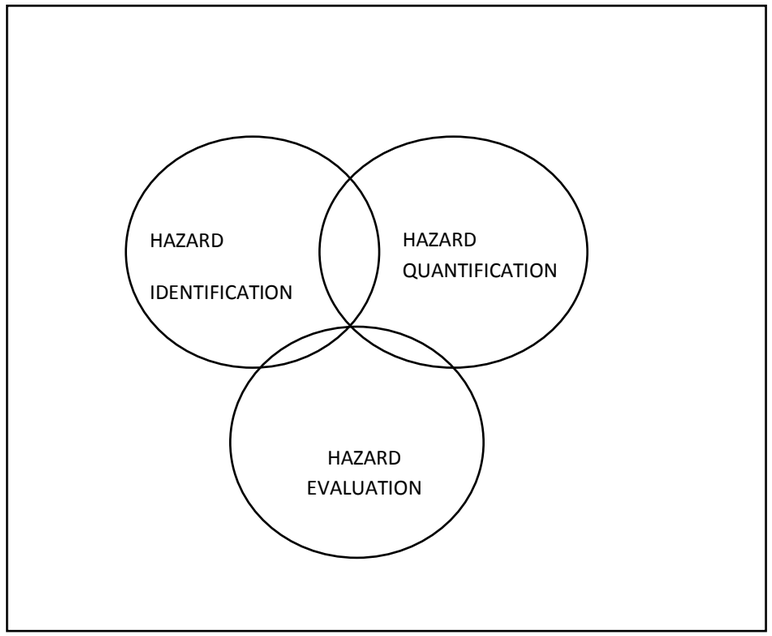

FIG. 1.2 - CONCEPTUAL ACTIVITIES: HAZARD STUDY AND RISK ANALYSIS

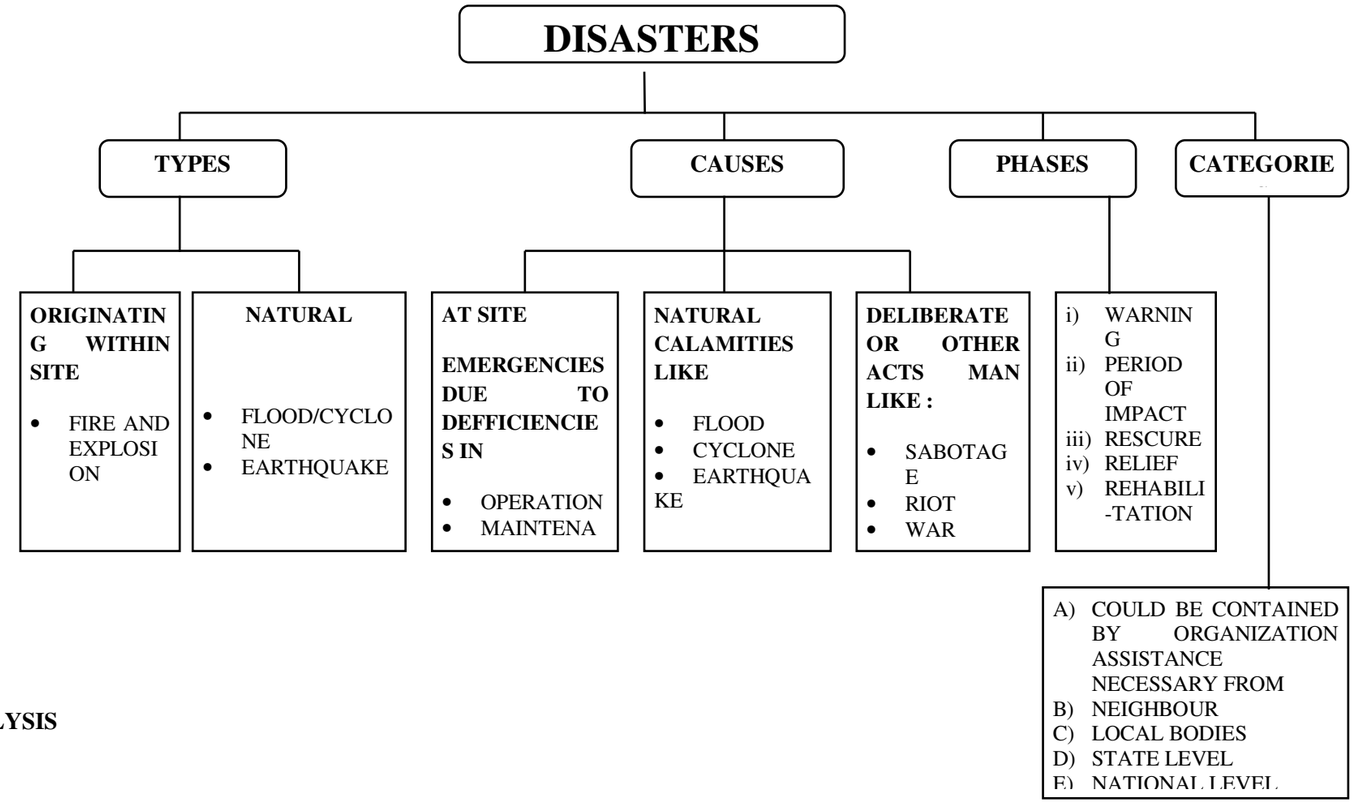

FIG. 1.1 DISASTER - TYPES, CAUSES, PHASES, AND CATEGORIES

4.2 RISK ANALYSIS MATRIX FOR PROPOSED COASTAL ROAD

Risk Mitigation Measures for Tunnels during Operations Phase

Sr. No.	Perceived Risks	Occurrence	Risk Mitigation Methods	
1.0	**Environmental**			
1.1	**Area prone to flooding**	Once a Year	a	All entry points to be covered from above to prevent rain water from directly falling on the ramps;
			b	Provide efficient drainage system with collection
			c	Provide Sumps to trap any water coming within the tunnel;
			d	Provide pumps to transfer any such water to external drains;
			e	Install systems to prevent entry of traffic into the tunnel in case of any eventuality;
			f	Install emergency communication methods for traffic to organize and evacuate themselves;
			g	Install quick evacuation methods for vehicles;
			h	Install dedicated emergency communication Systems at every 100 meters.
1.2	**Earthquake**	Once in 20 Years	a	Install systems to prevent entry of traffic into the tunnel in case of any eventuality;
			b	Install emergency communication methods for traffic to organize and evacuate themselves;
			c	Install quick evacuation methods for vehicles;
			d	Install dedicated emergency communication systems at every 100 meters.
1.3	**Internal Air Quality (IAQ)**	Daily	a	Install CO_2 and CO sensors at every 15 meters;
			b	Provide sufficient fresh air supply fans;
			c	Provide effective exhaust fans.

2.0	**User Related Risks**			
	Perceived Risks	**Occurrence**		**Risk Mitigation Methods**
2.1	**Accidents**	Weekly	a	Install cameras at every 30-50meters;
			b	Install incident reporting systems with ability to recognize stoppage in traffic flow, reverse traffic flow etc. in lanes;
			c	Identify methods to enable emergency services to access accident sites quickly;
			d	Install systems to prevent entry of traffic into the tunnel in case of any eventuality;
			e	Install emergency communication methods for traffic to organize and evacuate themselves;
			f	Install quick evacuation methods for vehicles;
			g	Install dedicated emergency communication system at every 100 meters.
2.2	**Congestion/Breakdown/**	Daily	a	Install variable message system
	Stoppage/ Lane Changing/		b	Install fixed sign system
	Drunk/ Rash Driving/		c	Install cameras at every 30~50meters;
	Over Speeding		d	Install incident reporting systems with ability to recognize stoppage in traffic flow, reverse traffic flow etc. in lanes;
			e	Identify methods to enable emergency services to access accident sites quickly;
			f	Install systems to prevent entry of traffic into the tunnel in case of any eventuality;
			g	Install emergency communication methods for traffic to organize and evacuate themselves;
			h	Install quick evacuation methods for vehicles;
			i	Install pedestrian exit routes at every 500 meters;
			j	Install dedicated emergency communication systems at every 100 meters.
2.3	**Hazardous/ Poisonous Gases**	Rare	a	Prevent entry of tankers, articulated long trucks and oversized vehicle into the tunnel;
			b	Provide margin for vehicular rejection atleast 50 meters before tunnel entry to divert these vehicles to other lanes
			c	Install sign boards outside the tunnel for vehicles to Organize themselves and move to other lanes.
			d	Provide sufficient fresh air supply fans;
			e	Provide effective exhaust fans.

Operational/Maitenance Risks			
Perceived Risks	**Occurrence**		**Risk Mitigation Methods**
Fire	Once a Year	a	Install SCADA systems for monitoring all Equipment installed in the tunnels;
		b	Ensure only 'Plug and Play' equipments are installed;
		c	Install quick response fire detection systems in the tunnel;
		d	Install cameras with ability to recognize fire hazards every 30 – 50 m;
		e	Install Fixed Fire Fighting (FFF) and automatically Systems within the tunnel;
		f	Install smoke evacuation systems;
		g	Identify methods to enable emergency services to access accident sites quickly;
		h	Install systems to prevent entry of traffic into the tunnel in case of any eventuality;
		i	Install emergency communication methods for traffic to organize and evacuate themselves;
		j	Identify quick evacuation methods for vehicles;
		k	Identify quick evacuation methods for pedestrians;
		l	Install dedicated emergency communication system at every 100 meters.
Power Outage in Tunnels	Once in 6 Months	a	Provide UPS supply to all emergency equipment
			and at least 1/3 rd of the lights;
		b	Provide secondary source of power supply like DG
			sets;
		c	Install spare HT cables to transformers for
			Redundancy.
Equipment Failure	Monthly	a	Install SCADA systems for monitoring all
			Equipment installed in the tunnels;
		b	Ensure only 'Plug and Play' equipments are installed;
		c	Ensure adequate spare parts/ replacements to
			Minimize equipment downtime.
Security Risks			
Terrorist Attacks	Once in 2 Years	a	Install cameras at every 30~50meters;
		b	Install incident reporting systems with ability to
			recognize stoppage in traffic flow, reverse traffic
			flow etc. in lanes;
		c	Install systems to prevent entry of traffic into the
			tunnel in case of any eventuality;
		d	Install emergency communication methods for
			traffic to organize and evacuate themselves;
		e	Identify quick evacuation methods for vehicles;
		f	Identify quick evacuation methods for pedestrians;
		g	Install dedicated emergency communication
			systems at every 100 meters.

4.3 Risk Assessment for Tunnel

Risk assessment is essential part of tunnel services and structural design. This has been considered in related to various incident scenarios which may occur during operation of the proposed tunnels. Risk analysis is based on risk rating of various incidents and their impact on the proposed tunnel structure and users.

Structural measures	Twin tubes Mandatory where a 15-year forecast shows that traffic > 10 000 vehicles /lane.	Twin/ Multiple uni-directional tunnels proposed
		Gradients shall be restricted to 4%
	Emergency walkways are mandatory where no emergency lane is provided	Provision of emergency walkway is proposed
	Emergency exits every 500m are mandatory	Cross connections proposed at every 500m
	Mandatory cross-connections for emergency services at least every 1 500 m	Cross connections proposed at every 500m
	Crossing of the central reserve outside each portal (mandatory requirement)	It is proposed to provide continuous cut section to adopt the same
	Drainage for flammable and toxic liquids is mandatory where such goods vehicles are allowed	Although such inflammable and toxic goods carrying vehicles will be rejected. Drainage provisions have been made underneath the pavement
	Fire resistance of structures is mandatory where local collapse of structure may have disastrous effect	Complied by making such provisions
Lighting	Normal Lighting	Proposed as per CIE 88, 2004
	Safety lighting	Proposed as per CIE 88, 2004
	Evacuation lighting	Provided over footways
Ventilation	Mechanical ventilation	Proposed longitudinal ventilation by providing jet fans
	Mandatory semi transverse ventilation for tunnels of more than 3000m length	Provisions made through supply ducts and ventilation shafts.
Emergency stations	Mandatory provision of emergency stations at 150m equipped with telephone and two fire extinguishers necessary	Provision to be made at every 150m.
Water supply	At every 250m	Water supply pipe attached to water tank to be provided with supply point at every 150m to match location of emergency station.
Road signs	Mandatory	Provided with road signs

Control center	Surveillance of several tunnels may be centralized into a single control centre.	Two control centers shall be provided first near Priyadarshini Park and second near Rutumbhara college to cover two tunnel sections. The Control Centers are located at start of tunnel as well as center of South and North section of Coastal Road to respond to incident on entire stretch with provision of SCADA.
Monitoring systems	Video	CCTV cameras shall be provided along tunnels as well as along Coastal Road
	Automatic incident detection and/or fire detection	SCADA system connected to CCTV equipped with automatic incident detection system and response is proposed.
Equipment to close tunnel	Traffic signals before the entrances	The mandatory provision is to be complied by provision of gate controlled from Control center
	Traffic signals inside the tunnel	It is proposed to provide traffic signals at every 500m before every cross connection to enable traffic diversion to parallel tunnel in case of incident.
Communications system	Radio re-broadcasting for emergency services	Provisions made connected to SCADA system
	Emergency radio messages for tunnel users	Provisions made connected to SCADA system
	Loudspeakers in shelters and exits	Provisions made connected to SCADA system
Emergency power supply	Mandatory	It is proposed to equip control center with necessary capacity of standby generators with necessary fuel storage
Fire resistance of equipment	Mandatory	All tunnel fixtures and fitting shall be fire resistance compliant.
Additional Provisions	Drainage	It is proposed to provide sump and pumping arrangement to collect seepage/ storm water at lowest point of tunnels and dispose the same to sea.
	Leaky feeder cable	It is proposed to provide leaky feeder cable to enable use of mobile services within tunnels.
	Environmental monitoring censors	It is proposed to provide environmental monitoring censors to monitor visibility levels, air quality and smoke detection
	Linear Heat Detection	Linear heat detection is proposed through adoption of OFC cables cross looped to detect exact location of fire.
	Variable Message signs	It is proposed to provide VMS system attached to SCADA at control center to enable safe tunnel operation.

Event Probability:

Description	Scenario	Probability
Highly likely	Very frequent occurrence	Over 85%
Likely	More than even chance	51-85%
Fairly likely	Occurs quite often	21-50%
Unlikely	Could happen but not very often	1-20%
Very unlikely	Occurrence is not expected to happen	Less than 1-0.01%
Extremely unlikely	Just possible but very surprising	Less than 0.01%

Event Impact:

Description	Scenario Examples
Disastrous	Tunnel operation could not be sustained
Severe	Serious threat to tunnel operations
Substantial	Increases operational costs/difficulties substantially
Marginal	Small effect on operational cost /difficulty
Negligible	Trivial effect

4.4 Risk response strategies

Risk Action Required	Possible Response
Elimination	Change provision such as that risk cannot occur.
Avoidance	Modify provision so that risk greatly reduced.
Transfer	Not likely to be able to do this for safety aspects.
Mitigation	Measures taken to reduce impact of risk if it were to occur
Acceptance	It is an accepted risk and it is negligible or there are no cost effective solutions available.

Vehicle related incidents: Tunnels are designed to carry traffic loading and there are events of varying probability which may affect safe operation of the tunnel.

- **Fire in the Tunnel:**

Fires in tunnel are a serious risk and the probability of such incidence is based on likelihood of a serious accident occurring inside the proposed tunnel and the vehicle involved catching fire. Tunnel alignment have been maintained as straight alignment with maximum grade of 4% allowing high visibility distance. **It is proposed to prohibit all vehicles carrying flammable and dangerous goods on entire Coastal Road**. This is to eliminate risk of such vehicle entering in to tunnels and getting involved in to an accident. Such type of vehicles may cause fires of up to 100MW having disastrous effect on tunnel structure. Based on present traffic volumes the HGV percentage is likely to be less than 5% of overall traffic volume. Hence a 50MW fire (BD 78/99 table 8.2) is adopted for design of ventilation to bring the impact to an acceptable level.

- **Accidents:**

Probability of occurrence of accident in an uni-directional tunnel is very unlikely. To reduce the probability of same to extremely unlikely event, alignment of the tunnels has been designed as straights with maximum grade of 4%. This will ensure high visibility to stopping vehicle/ debris on road. It is also proposed to restrict the vehicle speeds to 80Kmph for entire coastal road and enforce the same through speed detection cameras.

- **Breakdown and debris on road:**

Risk of occurrence of such event is similar to accidents. Automatic incident detection system shall be implemented to reduce the impact of such event.

- **Oversize vehicles:**

It is proposed to restrict entry of all over sized vehicles on Coastal Road to eliminate such risk.

Non Vehicle related incidences

- **Vandalism:**

Vandalism: considering that this is an urban tunnel, it is necessary to provide for securitization of likely entry points to the tunnels by pedestrians. Such a vandalism event may have very high impact on tunnel services. Therefore control room shall be provided with automatic incident detection system to report stoppage of vehicles and presence of pedestrian inside tunnel. Control rooms shall be manned 24x7 to register and act on such incidence. However to eliminate risk of this high impact event, the SCADA software shall be capable of sending message to enforcement agency automatically with details of location.

- **Terrorist Attack:**

Impact of such event on tunnel operation would be disastrous and would require immediate action by local police who would be informed by the personnel manning the Emergency Control Centres. The method of reducing risk of such event shall be discussed with the Authority.

System will be provided so that the information will be intimated to the Police within a short period of time.

- **Traffic Queues:**

Risk of occurrence of traffic queues is unlikely considering adequate number of lanes has been proposed with adequate distances from tunnel entry/ exit points from proposed interchanges. However, event of traffic queuing is unlikely to impact on tunnel services. Environmental monitoring sensors are proposed to adjust level of tunnel services such as lighting and ventilation.

4.5 Modes of operation & Cause & Effect Matrix for Tunnel

Emergency Call System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
EMERGENCY CALL SYSTEM	ALARM MANUAL BUTTON	SOS Box Internal To Main Tunnel	Alarm	1) Immobile Vehicle 2) Health Trouble 3) Accident	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Amber flashing lights above SOS box for both traffic direction already activated at SOS box door opening	*
					3) Intercom communication and emergency call control unit recording system at main control centre already activated at SOS box door opening	*
					4) SOS box interior lighting already activated at SOS box door opening using Occupancy sensor	*
					5) CCTV camera shall capture the image of surrounding of respective SOS box and same shall be available on operator CCTV monitors at main/redundant control centre	*
					6) Alarm confirmation/authentication by operator at main control centre from camera live pictures, on basis alarm incident operator shall activate predefined mode of operation	#
					7) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light (if vehicle breakdown occurs with vehicle stopped inside tunnel out of lay-bay), traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol (if vehicle breakdown occurs with vehicle stopped inside tunnel (out of lay-by) TLTCs inside tunnel on red light to stop traffic before arriving to stopped vehicle, and on green light after stopped vehicle (if vehicle breakdown occurs with vehicle stopped inside tunnel out of lay-by), mechanical barrier at tunnel portal at closed position (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-by)	*
					8) Activation of tunnel communication system: transmission of message from Evacuative Broadcasting system by operator	#
					9) Application of all the emergency standards procedures according with emergency response plan (ambulance, police or breakdown truck are informed in order to give assistance to involved users) by the operator at main control centre	#
					10) Operator shall reset the system based on confirmation from emergency team	#

Access Control System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
ACCESS CONTROL SYSTEM	Door Position Sensor	Cross Passage Door	Door Opening Alarm	Emergency Condition	1) Announcement / visualization and alarm transmitted to operator at main/redundant control centre	*
					2) Alarm confirmation/authentication by operator at main control centre through CCTV system, on basis alarm incident operator shall activate predefined mode of operation	#
					3) Activation of cross passage & escape tunnel emergency lighting system	*
					4) In case of Alarm: - Traffic outside the tunnel stopped from entering the tunnel, using TLTC on red light. - Signal to toll collection system to stop traffic - Traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol, message on DRIP to divert traffic to old route and SLVS for vehicle entry prohibition. Speed limit shall be reduced for SL installed inside tunnel.	*
					- TLTCs inside tunnel on red light to stop traffic before arriving to incident location, and on green light after incident location - Mechanical barrier at tunnel portal at closed position (only for entrance lanes) - Activation of tunnel communication system: alarm to be broadcast by operator in main via Evacuative Broadcasting System - Application of all the emergency standards procedures according with emergency response plan (ambulance, police or breakdown truck are informed in order to give assistance to involved users) by the operator at main control centre	#
					5) If either MCP or ACS break glass is operated, emergency lighting shall be activated in cross passage after authentication by operator	*
					6) Operator shall reset the system based on confirmation from emergency team	#

Video Surveillance System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VIDEO SURVEILLANCE SYSTEM	AID DEVICE PER CAMERA INSIDE TUNNEL	Main tunnel (Fire zone every 75 m)	Stopped vehicle detected – Alarm	1) vehicle breakdown/ Accident	1) Alarm shall be transmitted to operator at main/redundant control centre	*
					2) alarm confirmation/authentication from operator at main control centre through CCTV system, on basis of alarm incident operator shall activate mode of operation	#
					3) speed limit reduced externally and internally to tunnel using SLV lights with amber flashing lights	*
					4)Traffic outside tunnel stopped before incident location inside tunnel, using TLTC on red light (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-bay), traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol (if vehicle breakdown occurring with vehicle stopped inside tunnel (out of lay-by). TLTCs inside tunnel on red light to stop traffic before arriving to stopped vehicle, and on green light after stopped vehicle (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-by), mechanical barrier at tunnel portal at closed position (if vehicle breakdown occurring with vehicle stopped inside tunnel out of lay-by). Message shall be sent to stop the vehicle entry into tunnel and EVS both side of tunnel shall turn to red cross to stop vehicles	*
			Rise of smoke Alarm	2) Fire incident	1) Alarm shall be transmitted to operator at main/redundant control centre	*
					2) Automatic prompt (POP-UP) of appropriate mode of operation for respective fire zone for confirmation by operator. If operator does not take any action within pre-defined time i.e. delay of 5min, system shall automatically activate the appropriate fire mode	#/*
					3) alarm confirmation/authentication from operator at main control centre through CCTV system	#
					4) Activation of escape tunnel pressurization fans of respective side of tunnel automatically after 1.5 minute of incident	*
					5) Activation of second escape tunnel pressurization fan manually by operator for fire mode.	#
					6) Motorized smoke damper (MSD) - 01, 02, 03 near fire location are fully open and all others will be closed (Typical scheme is followed for different fire zones as per mode of operation)	*
					7) TVS-S-01 / TVS-S-02 / TVS-N-01 / TVS-N-02 axial fans for fresh air supply are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation.	*
					8) TVE-S-02 / TVE-N-01 / TVE-N-02 axial fans for air/smoke extraction are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation.	*
					TVE-S-01 axial fan for air/smoke extraction is activated (Typical scheme is followed for different fire zones as per mode of operation). TVE-S-01 shall operate at 100%.	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Jet Fan control shall be enabled in fire mode only. Please refer Mode Table & Annexure 1 provided below:	
					JF-S-01 / JF-S-02 / JF-S-03 / JF-S-04 jet fans for longitudinal air speed control not activated	*
					AN-01 to AN-05 detect the air speed velocity and direction inside tunnel	*
					10) Anemometer/Velocity sensor from S to North and N to South detect the air velocity and direction inside the tunnel. If the velocity from both side of tunnel is equal between 1.0 to 1.6 m/sec, there is no activation of Jet Fans.	*
					11) If longitudinal air velocities from S to fire site and N to Fire site are different the following operation shall be applied;	*
					a) Air velocity from S to fire site is higher than the air velocity from N to fire site;	*
					· JF-N-01 & N-02 are activated	*
					· System shall keep observing the measurement for 3 mins with defined limits i.e. above 1.6 m/sec	*
					· If air velocity from S to fire site is still higher than the air velocity from N to fire site JF-N-03 & N-04 are also activated	*
					b) Air velocity from N to fire site is higher than the air velocity from S to fire site;	*
					· JF-S-01 & S-02 are activated	*
					· System shall keep observing the measurement	*
					· If air velocity from N to fire site is higher than the air velocity from S to fire site JF-S-03 & S-04 are also activated	*
					12) JF at respective portal do not operate if fire event happen within 300m zone from the portal entrance	*
					13) JF at other portal will operate manually if needed	#
					14) traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					15) traffic external to tunnel, in correspondence at circular intersection, redirected to the old road using information sign with VMS, DRIP	*
					16) traffic external to tunnel stopped before entering inside tunnel, using EVS on red light cross	*
					17) Traffic inside the tunnel stopped before arriving to fire zone, using TLTC on red light and TLS on red light cross however the system shall allow the vehicle to move out of tunnel after fire zone using TLTC on green light and TLS on green light arrow.	*
					18) mechanical barrier at tunnel portal at closed position	*
					19) Evacuative Broadcasting system & FM radio broadcast shall make global announcement for tunnel user to leave the tunnel	*
					20) activation of cross tunnel lighting system after authentication by operator	*
					21) Activation of signal to stop vehicle entry into disaster affected areas	*
					22) ACS, open three doors in Fire condition, each side of fire zone	*
					23) Operator shall reset the system based on confirmation from emergency team	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VIDEO SURVEILLANCE SYSTEM	AID DEVICE PER CAMERA	Main tunnel (Fire zone every 75 m) Inside tunnel	Pedestrian – Alarm	Person moving in tunnel	1) Alarm transmitted to operator at main/redundant control centre. Speed sign to reduce speed of vehicles. Traffic Lights shall turn to Amber.	*
					2) Manual announcement through evacuative Broadcasting system to assist the person	#
			Wrong way vehicle – Alarm	Vehicle moving in wrong direction	1) Alarm transmitted to operator at main/redundant control center	*
					2) TLTCs inside tunnel on red light to stop traffic before arriving near to person/vehicle, and on green light after moved person/vehicle to lay-bay. After authentication by operator.	#
					3) Manual announcement through FM to warn the wrong way driver.	#
			Fallen object – Alarm	An object/ material fallen on the road	1) Alarm transmitted to operator at main/redundant control center.	*
					2) After authentication appropriate mode of operation shall be activated by operator	#
					2) TLTCs inside tunnel on red light to stop traffic before arriving near to person/vehicle, and on green light after moved person/vehicle to lay-bay. After authentication by operator. Speed reduced through SLV's before the fallen object.	*
					3) Manual announcement: operator to announce appropriate message through EBS & FM radio.	#
					4) Emergency Response team to clear the fallen object.	#
			Camera Failure alarm	Network communication /Power failure	1) Alarm transmitted to operator at main/redundant control center.	*
			AID Failure alarm	Video Loss	2) Appropriate action to be taken by operator to inform maintenance team to rectify the fault.	#
			Speed Drop	Stopped vehicle/ Slow moving vehicle	1) Announcement of appropriate message on FM radio by operator. Adjust speed limit signs.	#

Ventilation System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VENTILATION SYSTEM	NORMAL OPERATING CONDITIONS					
	CARBON MONOXIDE DETECTOR cum OPACITY	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2),	Measured Value Of Concentration Of CO/ OP	CO Concentration ≥ 70ppm/ OP Extinction	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Smoke extract dampers (from MSD-01 to MSD-45 if detected CMD/OPD at CPs 02,04,…….14)/(from MSD-46 to MSD-90 if detected CMD/OPD at CPs 16,18,…….28) in normal open mode	*

	(VISIBILITY) DETECTOR	CP's 12-14 (Zone-3) CP's 16-18 (Zone-4) CP's 20-22 (Zone-5) CP's-24-26-28 (Zone-6)	Level	Factor ≥ 0.006m-¹ For Duration T > 3 Min	3) Opening of Non Return Damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28) as per mode of operation	*
					4) Feedback from limit switch of Non Return damper (NRD) for TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					5) Activate FAN at 25 % speed TVE-S-1 (CPs 02,04,…….14) / TVE-N-1 (CPs 16,18,…….28)	*
					6) Fan run/stop status via air flow switch	*
					7) Opening of Non Return Damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					8) Feedback from limit switch of Non Return damper (NRD) for TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					9) Activate FAN at 25 % speed TVS-S-1 (CPs 02,04,…….14) / TVS-N-1 (CPs 16,18,…….28)	*
					10) Fan run/stop status via air flow switch	*
					11) TVS-S-1 and TVE-S-1 (CPs 02,04,…….14) / TVS-N-1 and TVE-N-1 (CPs 16,18,…….28) stopped when CO concentration/OP extinction staying at ≤ 50ppm/0.004m-¹ for more than 3 mins.	*
					12) If CO level is < 50 ppm and OP < 0.0040 then all TVE & TVS FAN shall be switched off.	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
VENTILATION SYSTEM	NORMAL OPERATING CONDITIONS - STOPPED TRAFFIC (TUNNEL CLOSURE)					
	CARBON MONOXIDE DETECTOR cum OPACITY (VISIBILITY) DETECTOR	CPs 02-04-06 (Zone1), CP's 08-10 (Zone-2), CP's 12-14 (Zone-3) CP's	Measured Value Of Concentration Of CO/ OP Level	CO Concentration ≥ 200ppm/ OP Extinction Factor ≥ 0.012m-¹	1) Alarm transmitted to operator at main/redundant control centre	*
					2) Image of spot will be captured by CCTV and will be available at operators monitor	*
					3) Alarm confirmation/authentication from operator at main control centre through CCTV system	#
					4) Traffic stopped in front of tunnel portal using TLTC on red light	*

		16-18 (Zone-4) CP's 20-22 (Zone-5) CP's-24-26-28 (Zone-6)		Duration Of Detection T ≥ 3min	5) Traffic stopped in front of tunnel portal using EVS on red cross symbol	*
					6) Traffic redirected to the old road using information sign with VMS at circular intersection & DRIP to divert traffic to old route	*
					7) Using of mechanical barrier for closing tunnel to traffic	*
					8) Activation of tunnel communication system: transmission of predefined phonetic messages on FM radio and EBS (users informed to shut off the vehicle engine in case of stopped traffic) via Evacuative Broadcasting system and FM Radio.	#
					9) Alarm sent to toll plaza to stop tolling and vehicle entry to tunnel	*
					10) Application of all the emergency standards procedures according with emergency response plan (ambulance, police or breakdown truck are informed in order to give assistance to involved users) by the operator at main control centre.	#
					11) Operator shall reset the system based on confirmation from emergency team	#
					12) All MT supply & Exhaust fans operate at 100% until the sensor measure lower levels & the fans can be adjusted accordingly	*

Electrical Fire Signalling System

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
EFSS	LINEAR HEAT DETECTOR	Main Tunnel (Fire zone at every 75 m Typical)	Heat Detection Alarm	Heat Raised Or Fire Occurred	1) Alarm shall be transmitted to operator at main/redundant control centre	*
					2) Automatic prompt (POP-UP) of appropriate mode of operation for respective fire zone for confirmation by operator. If operator does not take any action within pre-defined time i.e. delay of 5min, system shall automatically activate the appropriate fire mode	#/*
					3) Alarm confirmation/authentication from operator at main control centre through CCTV system	#
					4) Activation of escape tunnel pressurization fans respective side of tunnel shall be automatically start after 1.5 minute of fire incident	*
					5) Activation of second escape tunnel pressurization fans manually by operator for fire mode	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					6) Motorized smoke damper (MSD) - 01, 02, 03 near fire location are fully open and all others will be closed (Typical scheme is followed for different fire zones as per mode of operation)	*
					7) TVS-S-01 / TVS-S-02 / TVS-N-01 / TVS-N-02 axial fans for fresh air supply are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation	*
					8) TVE-S-02 / TVE-N-01 / TVE-N-02 axial fans for air/smoke extraction are stopped (Typical scheme is followed for different fire zones as per mode of operation) immediately after confirmation	*
					9) TVE-S-01 axial fan for air/smoke extraction is activated (Typical scheme is followed for different fire zones as per mode of operation). TVE operates at 100% .	*
					Jet Fan control shall be enabled in fire mode only. Please refer Mode Table & Annexure 1 provided below:	
					· JF-S-01 / JF-S-02 / JF-S-03 / JF-S-04 jet fans for longitudinal air speed control not activated	*
					· AN-01 to AN-05 detect the air speed velocity and direction inside tunnel	*
					10) Anemometer/Velocity sensor from S to North and N to South detect the air velocity and direction inside the tunnel. If the velocity from both side of tunnel is equal between 1.0 to 1.6 m/sec, there is no activation of Jet Fans.	*
					11) If longitudinal air velocities from S to fire site and N to Fire site are different the following operation shall be applied;	*
					a) Air velocity from S to fire site is higher than the air velocity from N to fire site;	*
					· JF-N-01 & N-02 are activated	*
					· System shall keep observing the measurement for 3 mins with defined limits i.e. above 1.6 m/sec	*
					· If air velocity from S to fire site is still higher than the air velocity	*

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					from N to fire site JF-N-03 & N-04 are also activated	
					b) Air velocity from N to fire site is higher than the air velocity from S to fire site;	*
					· JF-S-01 & S-02 are activated	*
					· System shall keep observing the measurement	*
					· If air velocity from N to fire site is higher than the air velocity from S to fire site JF-S-03 & S-04 are also activated	*
					12) JF at respective portal do not operate if fire event happen within 300m zone from the portal entrance	*
					13) JF at other portal will operate manually if needed	
					14) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light	*
					15) Traffic external to tunnel, in correspondence of at circular intersection, redirected to the old road using information sign with VMS, DRIP	*
					16) Traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol	*
					17) Traffic inside the tunnel stopped before arriving to fire zone, using TLTC on red light and TLS on red cross symbol however the system shall allow the vehicle to move out of tunnel after fire zone using TLTC on green light and TLS on green arrow symbol	*
					18) Mechanical barrier at tunnel portal at closed position	*
					19) FM rebroadcasting system and Evacuative Broadcasting system shall announce global announcement for tunnel user to leave the tunnel	*
					20) Activation of escape tunnel lighting system	*
					21) Activation of signal to Toll Plaza to stop vehicle tolling and entry	*
					22) ACS, open three doors in Fire condition, each side of fire zone	*
					23) Operator shall reset the system based on confirmation from emergency team	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
EFSS	Manual Call point	Escape door, inside Main tunnel	Manually Generated Fire Alarm	Fire event	1) Fire alarm announced in the main/redundant control centre by alarm facilities	*
					2) Alarm confirmation/authentication through emergency team visit to respective location	#
					a) EFS central resetted, in case of false alarm b) In case of real alarm, operator shall take manual action as per standard operating procedure in emergency response plan like call fire brigade	#
					c) Switch on escape tunnel lights d) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light and EVS on red cross symbol e) Traffic external to tunnel at circular intersection, redirected to the old road using information sign with VMS, DRIP f) Traffic inside the tunnel stopped before arriving to fire site, using TLTC on red light and TLS on red cross symbol, traffic after the fire site will be let out of tunnel using TLTC on green light and TLS on green arrow symbol g) Mechanical barrier at tunnel portal at closed position (only for entrance lanes) h) FM rebroadcasting system and Evacuative Broadcasting system shall announce global announcement for tunnel user to leave the tunnel	*
					i) Activation of signal to stop vehicle entry into affected areas j) ACS, open three doors in Fire condition, each side of fire zone	*
					Operator shall reset the system based on confirmation from emergency team	#
EFSS	EFS DISCRETE DETECTORS	Technical Rooms, LV Rooms External/Internal To	Automatic Fire/Smoke Alarm	Smoke Occurred	1) Fire alarm announced in the main/redundant control centre by alarm facilities	*
					2) Alarm confirmation/authentication through emergency team visit to respective location	#
					a) EFS central resetted, in case of false alarm	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
		Tunnel			b) In case of real alarm, operator shall take manual action as per standard operating procedure in emergency response plan like call fire brigade	
					c) Switch on escape tunnel lights d) Traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light and EVS on red cross symbol e) Traffic external to tunnel at circular intersection, redirected to the old road using information sign with VMS, DRIP f) Traffic inside the tunnel stopped before arriving to fire site, using TLTC on red light and TLS on red cross symbol, traffic after the fire site will be let out of tunnel using TLTC on green light and TLS on green arrow symbol g) Mechanical barrier at tunnel portal at closed position (only for entrance lanes) h) FM rebroadcasting system and Evacuative Broadcasting system shall announce global announcement for tunnel user to leave the tunnel	*
					i) Activation of signal to stop vehicle entry into affected area/stretch j) ACS, open three doors in Fire condition, each side of fire zone	*
					Operator shall reset the system based on confirmation from emergency team	#
Traffic control system	ESD/EOD/EHD	In the way of the bridge road gantry at both north and south portal	Smoking vehicle detected/Excessive heated vehicle detected/Excessive height vehicle detected	Excessive Smoke generated by vehicle/ Heat generated by vehicle greater than defined value /height of vehicle greater than defined value	Alarm announced in the main/redundant control centre by alarm facilities	*
					Alarm confirmation/authentication through emergency team visit to respective location	#
					Mechanical barrier to closed position	*
					vehicle redirected to the old road using TLTC with direction symbol	
					traffic signs shall glow and Appropriate message shall be displayed on DRIP	
					alarm to security staff	#
					Operator shall check the authenticity of alarm and reset the system to open the Boom Barrier	#

SYSTEM	DEVICE	LOCATION	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)

Electrical System Cause & Effect Matrix

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
PLC inside HT Panel	HT-SS1, HT-SS2, HT-SS3, HT-SS4, HT-SS5	NORMAL			Normal Mode (Power supply from South Grid HEALTHY; North Grid HEALTHY): Power supply from South Grid feeds the entire tunnel. The Main incomer breaker at HT-SS1 CLOSE. Main-incomer breaker at HT-SS5 OPEN. All Tie-breakers CLOSE.	*
			VOLTAGE = 0 at HT-SS1 Incomer Breaker	Grid Supply FAIL	(Power supply from South Grid FAIL; North Grid HEALTHY): Action PSS PLC: 1. Check grid-supply from South FAIL. The Main incomer breaker at HT-SS1 OPEN. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. All Tie-breakers CLOSE. 2. The entire tunnel re-energized from North-Grid supply. 3. Once South-Grid power supply is restored, return to Normal Mode after 1 hour	*
			VOLTAGE = 0 at HT-SS1 Incomer Breaker, HT-SS5 Incomer Breaker		(Power supply from South Grid FAIL; North Grid FAIL): Action PSS: 1. Check grid-supply from South FAIL. The Main incomer breaker at HT-SS1 OPEN. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1, HT-SS2, HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. Follow Tunnel Close-down procedure as mentioned below	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
			VOLTAGE = 0 at HT-SS2 Tie-Breaker-1	Cable damage between HT-SS1 and HT-SS2	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS1 and HT-SS2 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS2, HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS1 and HT-SS2	*
			VOLTAGE = 0 at HT-SS2 Tie-Breaker-1, HT-SS5 Incomer Breaker		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS: 1. Tie-breakers between HT-SS1 and HT-SS2 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS2, HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. Follow Tunnel Close-down procedure.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from	#

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					electrical maintenance team.	
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected areas/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
			VOLTAGE = 0 at HT-SS3 Tie-Breaker-1	Cable damage between HT-SS2 and HT-SS3	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS2 and HT-SS3 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS1 and HT-SS2 CLOSE, between HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS2 and HT-SS3	*
			VOLTAGE = 0 at HT-SS3 Tie-Breaker-1, HT-SS5 Incomer Breaker		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS: 1. Tie-breakers between HT-SS2 and HT-SS3 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1 and HT-SS2 CLOSE. Tie-breakers between HT-SS3, HT-SS4 and HT-SS5 CLOSE. 2. Follow Tunnel Close-down procedure	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
			VOLTAGE = 0 at HT-SS4 Tie-Breaker-1	Cable damage between HT-SS3 and HT-SS4	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS3 and HT-SS4 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS1 HT-SS2 and HT-SS3 CLOSE, between HT-SS4 and HT-SS5 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS3 and HT-SS4	*
			VOLTAGE = 0 at HT-SS4 Tie-Breaker-1, HT-SS5 Incomer Breaker		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS: 1. Tie-breakers between HT-SS3 and HT-SS4 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1, HT-SS2 and HT-SS3 CLOSE. Tie-breakers between HT-SS4 and HT-SS5 CLOSE. 2. Follow Tunnel Close-down procedure	*
					Action by ITCS;	

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
		9	VOLTAGE = 0 at HT-SS5 Tie-Breaker	Cable damage between HT-SS4 and HT-SS5	(Power supply from South Grid HEALTHY; North Grid HEALTHY): Action PSS: 1. Tie-breakers between HT-SS4 and HT-SS5 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North HEALTHY. Main-incomer breaker at HT-SS5 CLOSE. Tie-breakers between HT-SS1, HT-SS2, HT-SS3 and HT-SS4 CLOSE. 2. The entire tunnel re-energized from South-Grid and North-Grid supply. 3. Maintenance works to be carried out between HT-SS4 and HT-SS5	*
		10	VOLTAGE = 0 at HT-SS5 Tie-Breaker, HT-SS5 Incomer Breaker		(Power supply from South Grid HEALTHY; North Grid FAIL): Action PSS: 1. Tie-breakers between HT-SS4 and HT-SS5 OPEN. Check grid-supply from South HEALTHY. The Main incomer breaker at HT-SS1 CLOSE. Check grid-supply from North FAIL. Main-incomer breaker at HT-SS5 OPEN. Tie-breakers between HT-SS1, HT-SS2, HT-SS3 and HT-SS4 CLOSE. 2. Follow Tunnel Close-down procedure	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					Normal Mode (All Transformers HEALTHY at Technology Building): ACB Nos B1, B3, B5, B7, B9, B11 CLOSE; B2, B4, B6, B8, B10 OPEN	*
PLC inside LT Panel	MDB-SS1	NORMAL				
			VOLTAGE = 0 at MDB-SS1	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS1-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS1-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS1-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8 and B10 OPEN. If YES, CLOSE ACB B2. 3. Power supply restored to MDB-SS1. 4. Maintenance works to be carried out at TX-SS1-1	*
			VOLTAGE = 0 at MDB-SS1	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS1-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS1-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS1-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					and B10 OPEN - if any breaker CLOSE, ACB B2 remains OPEN. 3. Follow Tunnel Close-down procedure	
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					Maintenance personnel to inspect TX-SS1-1 and restore power supply to MDB-SS1	*
			VOLTAGE = 0 at MCP-AF1-VB1	ACB-B5 TRIP/ OPEN	(TRANSFORMER TX-SS1-3 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF3-VB1 (Exhaust Fan-1) 2. Check TX-SS1-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS1-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If YES, CLOSE ACB B4. 4. Power supply restored to MCP-AF1-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB1 and MCP-AF3-VB1 6. Maintenance works to be carried out at TX-SS1-3	*
			VOLTAGE =	ACB-B5 TRIP/	(TRANSFORMER TX-SS1-3 (1250kVA FAIL):	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
			0 at MCP-AF1-VB1	OPEN	Action PSS PLC: 1. Turn-off MCP-AF3-VB1 (Exhaust Fan-1) 2. Check TX-SS1-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS1-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If NO, ACB B4 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan	
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					Maintenance works to be carried out at TX-SS1-3	
			VOLTAGE = 0 at MCP-AF2-VB1	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS1-4 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF4-VB1 (Exhaust Fan-2) 2. Check TX-SS1-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS1-5 OPEN.	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If YES, CLOSE ACB B6. 4. Power supply restored to MCP-AF2-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB1 and MCP-AF4-VB1. 6. Maintenance works to be carried out at TX-SS1-4	
			VOLTAGE = 0 at MCP-AF2-VB1	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS1-4 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF4-VB1 (Exhaust Fan-2) 2. Check TX-SS1-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS1-5 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If NO, ACB B6 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on	#

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					confirmation ITCS operator shall reset the system.	
					5. Maintenance works to be carried out at TX-SS1-4	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB1 (Supply Fan-1) 2. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If YES, CLOSE ACB B6. 4. Power supply restored to MCP-AF3-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB1 and MCP-AF3-VB1. 6. Maintenance works to be carried out at TX-SS1-5	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB1 (Supply Fan-1) 2. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, ACB B8 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS1-5	*
			VOLTAGE = 0 at MCP-AF4-VB1	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS1-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB1 (Supply Fan-2) 2. Check TX-SS1-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS1-7 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If YES, CLOSE ACB B10. 4. Power supply restored to MCP-AF4-VB1. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB1 and MCP-AF4-VB1. 6. Maintenance works to be carried out at TX-SS1-6	*
			VOLTAGE = 0 at MCP-AF4-VB1	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS1-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB1 (Supply Fan-2) 2. Check TX-SS1-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS1-7 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If NO, ACB B10 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS1-6	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 2. Check MCP-AF4-VB1 ACB B11 HEALTHY. If YES, Turn ON MCP-AF4-VB1. 3. Maintenance works to be carried out at TX-SS1-5	*
			VOLTAGE = 0 at MCP-AF3-VB1	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS1-5 (1250kVA FAIL): Action PSS PLC: 1. Check TX-SS1-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS1-6 OPEN. 2. Check MCP-AF4-VB1 ACB B11 HEALTHY. If NO, check power	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, OPEN the CLOSED Breaker. CLOSE ACB B8. 4. Power supply to MCP-AF3-VB1 restored 5. Turn-on MCP-AF3-VB1 and run Exhaust Fan-1 to 100% speed. 6. Maintenance works to be carried out at TX-SS1-5	
PLC inside LT Panel	MDB-SS5	NORMAL			Normal Mode (All Transformers HEALTHY at Technology Building): ACB Nos B1, B3, B5, B7, B9, B11 CLOSE; B2, B4, B6, B8, B10 OPEN	*
			VOLTAGE = 0 at MDB-SS5	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS5-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS5-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS5-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8 and B10 OPEN. If YES, CLOSE ACB B2. 3. Power supply restored to MDB-SS5. 4. Maintenance works to be carried out at TX-SS5-1	*
			VOLTAGE = 0 at MDB-SS5	ACB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS5-1 (750kVA FAIL): Action PSS PLC: 1. Check TX-SS5-1 parameters, TRIP. ACB B1 OPEN. VCB-HT-SS5-2 OPEN. 2. Check power supply at ACB B3 - HEALTHY. Check ACBs B4, B6, B8 and B10 OPEN - if any breaker CLOSE, ACB B2 remains OPEN. 3. Follow Tunnel Close-down procedure	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					4. Maintenance personnel to inspect TX-SS5-1 and restore power supply to MDB-SS5	*
			VOLTAGE = 0 at MCP-AF1-VB2	ACB-B5 TRIP/ OPEN	(TRANSFORMER TX-SS5-3 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF3-VB2 (Exhaust Fan-1) 2. Check TX-SS5-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS5-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If YES, CLOSE ACB B4. 4. Power supply restored to MCP-AF1-VB2. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB2 and MCP-AF3-VB2 6. Maintenance works to be carried out at TX-SS5-3	*
			VOLTAGE = 0 at MCP-AF1-VB2	ACB-B5 TRIP/ OPEN	(TRANSFORMER TX-SS5-3 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF3-VB2 (Exhaust Fan-1) 2. Check TX-SS5-3 parameters, TRIP. ACB B5 OPEN. VCB-HT-SS5-4 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B6, B8 and B10 OPEN. If NO, ACB B4 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Supply/ Exhaust fan.	
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS5-3	*
			VOLTAGE = 0 at MCP-AF2-VB2	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS5-4 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF4-VB2 (Exhaust Fan-2) 2. Check TX-SS5-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS5-5 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If YES, CLOSE ACB B6. 4. Power supply restored to MCP-AF2-VB2. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB2 and MCP-AF4-VB2. 6. Maintenance works to be carried out at TX-SS5-4	*
			VOLTAGE = 0 at MCP-	ACB-B7 TRIP/ OPEN	(TRANSFORMER TX-SS5-4 (1250kVA FAIL): Action PSS PLC:	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
			AF2-VB2		1. Turn-off MCP-AF4-VB2 (Exhaust Fan-2) 2. Check TX-SS5-4 parameters, TRIP. ACB B7 OPEN. VCB-HT-SS5-5 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B8 and B10 OPEN. If NO, ACB B6 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS5-4	*
			VOLTAGE = 0 at MCP-AF3-VB2	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB2 (Supply Fan-1) 2. Check TX-SS5-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					and B10 OPEN. If YES, CLOSE ACB B6. 4. Power supply restored to MCP-AF3-VB2. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF1-VB2 and MCP-AF3-VB2. 6. Maintenance works to be carried out at TX-SS5-5	
			VOLTAGE = 0 at MCP-AF3-VB2	ACB-B9 TRIP/ OPEN	(TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF1-VB2 (Supply Fan-1) 2. Check TX-SS5-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, ACB B8 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on	#

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					confirmation ITCS operator shall reset the system.	
					5. Maintenance works to be carried out at TX-SS5-5	*
			VOLTAGE = 0 at MCP-AF4-VB2	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS5-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB2 (Supply Fan-2) 2. Check TX-SS5-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS5-7 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If YES, CLOSE ACB B10. 4. Power supply restored to MCP-AF4-VB2. 5. Check ventilation parameters - if TWO FANS RUN, Turn-on MCP-AF2-VB2 and MCP-AF4-VB2. 6. Maintenance works to be carried out at TX-SS5-6	*
			VOLTAGE = 0 at MCP-AF4-VB2	ACB-B11 TRIP/ OPEN	(TRANSFORMER TX-SS5-6 (1250kVA FAIL): Action PSS PLC: 1. Turn-off MCP-AF2-VB2 (Supply Fan-2) 2. Check TX-SS5-6 parameters, TRIP. ACB B11 OPEN. VCB-HT-SS5-7 OPEN. 3. Check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B8 OPEN. If NO, ACB B10 remains OPEN. 4. Check if Tunnel can run with one number Supply Fan. If YES, alarm Toll-Plaza to maintain/ restrict traffic flow. If NO, follow TRAFFIC CONTROL procedure to restrict tunnel traffic so that it can run with one Supply/ Exhaust fan.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					5. Maintenance works to be carried out at TX-SS5-6	*
			VOLTAGE = 0 at MCP-AF3-VB2	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC: 1. Check TX-SS5-5 parameters, TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 2. Check MCP-AF4-VB2 ACB B11 HEALTHY. If YES, Turn ON MCP-AF4-VB2. 3. Follow TUNNEL FIRE MODE PROCEDURE 4. Maintenance works to be carried out at TX-SS5-5	*
			VOLTAGE = 0 at MCP-AF3-VB2	ACB-B9 TRIP/ OPEN	(FIRE INSIDE TUNNEL - TRANSFORMER TX-SS5-5 (1250kVA FAIL): Action PSS PLC: 1. Check TX-SS5-5 parameters TRIP. ACB B9 OPEN. VCB-HT-SS5-6 OPEN. 2. Check MCP-AF4-VB2 ACB B11 HEALTHY. If NO, check power supply at ACB B3 - HEALTHY. Check ACBs B2, B4, B6 and B10 OPEN. If NO, OPEN the CLOSED Breaker. CLOSE ACB B8. 4. Power supply to MCP-AF3-VB2 restored 5. Turn-on MCP-AF3-VB2 and run Exhaust Fan-1 to 100% speed. 6. Follow TUNNEL FIRE MODE PROCEDURE 7. Maintenance works to be carried out at TX-SS5-5	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
PLC inside LT Panel	MDB-SS2	NORMAL			Normal Mode (All Transformers HEALTHY at Sub-station 2 @ CP-08): MCCB Nos B1 CLOSED, B2 OPEN	*
			VOLTAGE = 0 at MDB-SS2	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS2-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS2-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS2-1 OPEN. 2. Check power supply at MCCB B2 - HEALTHY. CLOSE MCCB B2. 3. Power supply restored to MDB-SS2. 4. Maintenance works to be carried out at TX-SS2-1	*
			VOLTAGE = 0 at MDB-SS2	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS2-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS2-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS2-1 OPEN. 2. Check power supply at MCCB B2 - FAIL. Check Transformer TX-SS2-2 parameters, TRIP. MCCB B2 REMAINS OPEN. 3. Follow TUNNEL CLOSE-DOWN PROCEDURE.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	*
					Emergency response team shall confirm on healthy condition and based on	#

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					confirmation ITCS operator shall reset the system.	
					4. Maintenance works to be carried out at TX-SS2-1	*
PLC inside LT Panel	MDB-SS3	NORMAL			Normal Mode (All Transformers HEALTHY at Sub-station 2 @ CP-08): MCCB Nos B1 CLOSED, B2 OPEN	*
			VOLTAGE = 0 at MDB-SS3	MCCB-B1 TRIP/ OPEN	Mode-1 (TRANSFORMER TX-SS3-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS3-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS3-1 OPEN. 2. Check power supply at MCCB B2 - HEALTHY. CLOSE MCCB B2. 3. Power supply restored to MDB-SS3. 4. Maintenance works to be carried out at TX-SS3-1	*
			VOLTAGE = 0 at MDB-SS3	MCCB-B1 TRIP/ OPEN	Mode-2 (TRANSFORMER TX-SS3-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS3-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS3-1 OPEN. 2. Check power supply at MCCB B2 - FAIL. Check Transformer TX-SS3-2 parameters, TRIP. MCCB B2 REMAINS OPEN. 3. Follow TUNNEL CLOSE-DOWN PROCEDURE.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS on red cross symbol Alarm to toll plaza to stop toll collection and vehicle entry	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					4. Maintenance works to be carried out at TX-SS3-1	*
PLC inside LT Panel	MDB-SS4	NORMAL			Normal Mode (All Transformers HEALTHY at Sub-station 2 @ CP-08): MCCB Nos B1 CLOSED, B2 OPEN	*
			VOLTAGE = 0 at MDB-SS4	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS4-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS4-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS4-1 OPEN. 2. Check power supply at MCCB B2 - HEALTHY. CLOSE MCCB B2. 3. Power supply restored to MDB-SS4. 4. Maintenance works to be carried out at TX-SS4-1	*
			VOLTAGE = 0 at MDB-SS4	MCCB-B1 TRIP/ OPEN	(TRANSFORMER TX-SS4-1 (250kVA FAIL): Action PSS PLC: 1. Check TX-SS4-1 parameters, TRIP. MCCB B1 OPEN. VCB-HT-SS4-1 OPEN. 2. Check power supply at MCCB B2 - FAIL. Check Transformer TX-SS4-2 parameters, TRIP. MCCB B2 REMAINS OPEN. 3. Follow TUNNEL CLOSE-DOWN PROCEDURE.	*
					Action by ITCS;	
					Alarm shall appear on ITCS;	*
					Alarm authentication by operator manually after confirmation from electrical maintenance team.	#
					Mechanical barrier to closed position vehicle redirected to the old road using information sign with VMS, DRIP traffic external to tunnel stopped before entering inside tunnel, using TLTC on red light traffic external to tunnel stopped before entering inside tunnel, using EVS	*

DEVICE	LOCATION	MODE	ALARM / STATUS	CAUSE	(EFFECT) AUTOMATIC ACTION FROM INTEGRATED TUNNEL CONTROL (SCADA) OR MANUAL ACTION FROM OPERATOR	AUTOMATIC(*) / MANUAL(#)
					on red cross symbol Alarm to stop vehicle entry into affected area/stretches Operator to broadcast message on FM radio & Emergency broadcast system	
					Emergency response team shall confirm on healthy condition and based on confirmation ITCS operator shall reset the system.	#
					4. Maintenance works to be carried out at TX-SS4-1	*