



Inspection Manual for Dam Field Engineers after Seismic Events, Maithon Dam, Damodar Valley Corporation, Jharkhand

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February 2019

Prepared by
Japan Water Agency, Japan

Under the
Dam Rehabilitation and Improvement Project

Front Cover Photograph: Maithon Dam, Damodar Valley Corporation, Jharkhand.



Government of India
Central Water Commission
Central Dam Safety Organization

Inspection Manual for Dam Field
Engineers after Seismic Events,
Maithon Dam, DVC, Jharkhand

February 2019

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Government of India
Central Water Commission
Central Dam Safety Organization

The *Inspection Manual for Dam Field Engineers after Seismic Events, Maithon Dam, Damodar Valley Corporation (DVC), Jharkhand* has been published for the first time in February 2019 under the Dam Rehabilitation and Improvement Project (DRIP)

Disclaimer

The *Inspection Manual for Dam Field Engineers after Seismic Events, Maithon Dam, Damodar Valley Corporation (DVC), Jharkhand* in no way restricts the dam owner in digressing from it. The Central Dam Safety Organization or the Central Water Commission cannot be held responsible for the efficacy and sufficiency of procedures to be adopted after the seismic events. Appropriate discretion may be exercised while preparing and implementing evaluation and reporting mechanism in the case of seismic event.

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MESSAGE

India has more than 5200 large dams catering to water and power requirements of the country. Considering that most of the dams are designed to withstand the earthquake shocks as per the prevalent standard practices, it becomes of critical importance to ensure that the existing aging dams are safe in changing hydrological and seismic scenarios and continue to operate as designed producing benefits to the society.

Standards, practices and technology change with time and it is expected that dam engineers should be able to ensure the safety of our existing dams. For this purpose, World Bank took a lead for capacity enhancement of dam engineers in India by deputing a team of experts of Japan Water Agency to Maithon Dam of Damodar Valley Corporation (DVC), Jharkhand. All the dam safety aspects dealing with post seismic scenario were studied and documented. Engineers of the dam were trained by holding mock drills with practical and theoretical exercises. The study has been compiled and presented in the form of a Manual.

Every dam is unique. In the interest of dam safety, it is necessary to have operation and maintenance procedures for the functioning of all dams. In the same manner, there is a need to have post seismic event inspection manual for field engineers for each dam. The *Inspection Manual for Dam Field Engineers after Seismic Events, Maithon Dam, DVC* has been published as a case history. I sincerely believe that this compilation will help dam owners in India to make similar manuals catering to specific needs of each dam for enhancing the safety of their respective dams. I also urge each dam owner to conduct mock drills for this purpose at regular intervals.



(S Masood Husain)

Chairman

Central Water Commission

New Delhi
February 2019

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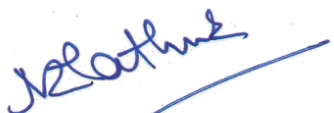
FOREWORD

A dam monitoring and inspection program provides the information that is needed to develop a better understanding of the performance of the dam. Knowing that the dam is performing as expected is reassuring to dam owners and other stakeholders including the general public and the ability to detect a change in this performance is critical for the dam owner who is directly responsible for any consequences. Seismic stability of our dams particularly in the highly seismic areas is of great concern and requires special attention. Based on dam inspections after the Seismic Event, the dam owners will be able to take needful actions to operate and maintain their dams in a safe manner through early identification and modification/ management/rectification.

The present *Inspection Manual for Dam Field Engineers after Seismic Events, Maithon Dam, Damodar Valley Corporation (DVC), Jharkhand* describes all elements of inspection and monitoring of existing dam after the occurrence of a seismic event. The various checklists required for discovering deficiencies if any after the occurrence of a seismic event have been explained in this manual. Instruments like seismographs and accelerographs required for measuring the seismic forces and the response of dams have also been explained in this manual. The manual details the best practices followed in Japan and elsewhere with the case history of Maithon dam in Jharkhand described in detail.

I hope that this manual will be quite useful to dam engineers for planning the comprehensive inspection programme including various checklists required for ensuring the safety of their respective existing dams. I compliment World Bank especially Dr. C Rajgopal Singh, Task Team Leader, DRIP, Japan Water Agency, Damodar Valley Corporation, Central Water Commission and all the individuals and organizations who have contributed towards the development of this Manual

New Delhi
February 2019


(N K Mathur)
Member (Design & Research)
Central Water Commission

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PREFACE

India ranks third in the world after China and the United States in terms of number of Dams. India has more than 5200 completed large dams besides several thousand smaller dams catering to the water and power requirements of the country. Most of these dams are operated and maintained by the State Governments. Some dams are also owned and operated by Private /Public sector agencies/organizations.

The primary objective of developing this Inspection Manual under the Dam Rehabilitation & Improvement Project (DRIP) is to provide guidance to the field engineers on operation and maintenance procedures, during and after the seismic activities, and to bring out the checklists of the activities needed to be performed by them after the seismic activities from the dam safety point of view.

Maithon dam of Damodar Valley Corporation (DVC) is a composite dam consisting of Concrete gravity dam and an Embankment dam. It is the second dam which has been taken up by the World Bank and Central Water Commission, after Ichari dam in Uttarakhand, for preparation of a Manual for its field engineers on the inspections to be conducted after seismic events.

The Manual has 9 chapters viz. Introduction, Scope of work, Work plan, Counterpart agencies, Project progress, Process for Maithon Dam Emergency Inspection, Field Drill, Earthquake Information System and Recommendations. It is supplemented by a large number of Appendices, figures and photographs for clarity. It covers the actions recommended by the Japan Water Agency (JWA) viz. Quick check, First Inspection and various actions like informing the DVC, State and Central Government agencies etc.

The Central Water Commission is grateful to World Bank and Japan Water Agency for value, support and contribution in bringing out state-of-the-art of knowledge in India for Dam Safety Management.

This Manual is intended to be used by engineers of Maithon dam, DVC for regular mock drills and ultimately for safety inspections after seismic events in the larger interest of ensuring a better operation and maintenance and safety for their dam. The DVC can adapt this manual for their other dams located in Himalayan region for better handling of any post-seismic disaster and Dam Safety Management.

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**The Consultancy Service for the Preparation of
Inspection Manual for Dam Field Engineers
after Seismic Events**

Final Report

Apr. 2018

Water supports wealthy society



Incorporated Administrative Agency
Japan Water Agency

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Abbreviations

CWC	Central Water Commission
DDMA	District Disaster Management Authority
DRIP	Dam Rehabilitation and Improvement Project
DVC	Damodar Valley Corporation
EAP	Emergency Action Plan
IMD	Indian Meteorological Department
JWA	Japan Water Agency

1. Introduction

1.1 Dams in India

India ranks third in the world after China and the United States in terms of number of dams. The dams have been playing a key role in fostering rapid and sustained agricultural and rural development. There are more than 4,800 completed large scale dams with a total storage of 253 billion cubic meters in India (An overview of water sector in India, Presentation by CWC, 2015). Most of these dams are operated and maintained by the state governments. A few public organizations also own and operate large dams and there are tens of thousands of medium and small scale dams owned by various agencies.

A significant number of dams are ageing and have various structural deficiencies as well as shortcomings pertaining to operation and monitoring facilities. As most of those large dams are highly hazardous, dam safety assurance is necessary to reduce risks and help assurance of sustainability and full operational capacity of existing storage through early identification and rectification of problems.

India has a long history of dam construction to manage limited water resources. The demand for water resources is still steadily increasing with the economic growth of India. As of the end of 2010, 4,800 large dams had been constructed. Among them, half of the dams are more than 25 years old and the number of old dams is on the rise year by year.

1.2 Dam Rehabilitation and Improvement Project

Given above mentioned background on large scale dams in India, Dam Rehabilitation and Improvement Project (hereafter DRIP) has been implemented since 2010 by the Government of India with financial assistance from the World Bank (hereafter WB). The objective of the project is to improve the safety and operational performance of selected existing dams in the territory of seven (7) participating states including Kerala, Tamil Nadu, Madhya Pradesh, Odisha, Karnataka and Uttarakhand (Uttarakhand Jal Vidyut Nigam Limited, hereafter UJVN Ltd.) and Jharkhand (Damodar Valley Corporation, hereafter DVC), which are deemed as pilot project sites considering large number of dams in the country.

The project activities focus not only on the rehabilitation and improvement of dam structures, but also address shortcomings in maintenance and provide for improvements

in operation of the dams. This will help keep dams and people in downstream safe.

1.3 Historical Earthquake in India

The bureau of Indian standards, Ministry of Earth Sciences, the Government of India is the official agency for publishing the seismic hazard maps and codes. Figure 1.1 shows the areal category regarding Earthquake Zones in Indian subcontinent. Zoning is defined based on the historical data values of maximum MM intensities recorded in various parts of the country in the past.

Geographical statistics of India show that almost 54% of the land is vulnerable to earthquakes. North and North East India are classified zone 4 or zone 5 which indicates the highest earthquake risk of strong intensity in the country.



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https://en.wikipedia.org/wiki/Earthquake_zones_of_India#/media/File:India_earthquake_zone_map_en.svg

Figure 1.1 Earthquake Zone Map of India

In 2015, Gorkha Earthquake centered in Nepal caused the severe damage in Nepal and India. More than 8,800 people were killed in Nepal, and more than 70 people in India. Fortunately, no serious damage to dams in India was reported. However, this earthquake raised awareness of the need for field engineers working at dam operation offices to respond systematically in order to secure the safety of dams.

In 2016, a magnitude 6.7 earthquake occurred in Manipur state, western India, and destroyed some buildings. The epicenter was 29km away from Imphal. In January 2018, there was another magnitude 6.1 earthquake in North-eastern India, on the Afghanistan-Tajikistan border.

1.4 Japan Water Agency

Japan Water Agency (hereafter JWA) is legally mandated to develop and manage water resources in seven major river basins in Japan. Up to 2016, JWA completed 30 dam construction projects including water resources development in natural lakes and approx. 5,500km irrigation channel construction and rehabilitation projects. All of the dams and related facilities completed under the above projects are now also operated and maintained by JWA.

As a managing organization of large scale hydraulic structures, JWA has been tackling earthquake countermeasures together with the other types of disasters from planning and designing stage till operation and maintenance stage. Earthquakes are very frequent in Japan. If any infrastructure is severely damaged by an earthquake, it would immediately affect people's lives and economy, and the restoration from the disaster would take a long time. In order to minimize such impacts, JWA established disaster prevention plans, checklists and manuals for daily operation, and has been periodically organizing drills with relevant organizations such as national government and local municipalities. This consultancy service aims to transferring JWA's experiences and knowledge on earthquake disaster prevention.

1.5 Regulatory Frameworks for Dam Safety in Japan

Following shows a history of development of regulatory frameworks on dam safety focusing particularly on earthquake-proof in Japan.

i) History of earthquake-proof design and safety control of dams in Japan

The oldest existing dam in Japan is the Sayama-Ike, earth fill dam, which was initially constructed in the early seventh century and is still functional for water supply and flood control. After the initial completion, it was renovated and raised several times for 1400 years up to now. When the major renovation was made in 1999, the detailed investigation of dam body was carried out and found that there were clear marks of damages by the significant earthquakes in the year of 734 and 1596 inside the dam body.

In 1925, Dr. Nagaho Mononobe, a Japanese prominent civil engineer, proposed the first theory of earthquake-proof design for dams which was titled "seismic coefficient method" in the world. Accordingly, a lot of large dams in Japan were designed and constructed based on his theory. Dr. Mononobe also established world epoch theory regarding infiltration and shear force of earth-fill dams, and made a great mark on enhancement of

dam engineering and dam safety in Japan. Dams in Japan designed based on the seismic coefficient method” showed high seismic resistances even when the 1995 Kobe earthquake and the other significant earthquakes hit.

In 1957, Japan Commission on Large Dams (JCOLD) compiled “the standard for dam design” which was developed based on the consistent philosophy on dam designing in consideration with existing Japanese dam construction technologies and also incorporating new ideas imported from USA and other countries. It has become a basis for design of dams in Japan.

In 1964, the structural criteria on dam engineering were legally authorized when the major revision of the river law was made. JCOLD also issued “the standard for monitoring structure of completed dams” in 1973. Following these actions, “the cabinet order concerning structural standards for river management facilities” was enacted in 1976, and current regulatory framework for dam safety was established. Specific standards and methodologies are stipulated in the subsequent orders issued by the Ministry of Construction (current Ministry of Land, Infrastructure, Transport and Tourism(MLIT)).

Regarding earthquake proof design, the ministerial order classifies the country into three zones by expected earthquake intensity; “strong earthquake zone” “medium earthquake zone” and “weak earthquake zone”, and defines design earthquake intensity coefficient of respective zone and type of dam structure. The design earthquake intensity is assumed strength of the quake which the target structure would experience once or twice during its life time.

These standards define that measurement items for the dam safety should be amount of water seepage, deformation of dam bodies, uplift pressure under basement of concrete dams, and surface line of seepage for homogeneous earth fill dams. In addition, further specific measurement items and standard interval of measuring them are defined for every structural type of dams, height of dam and stage of dam safety management after storing water firstly.

Seismic movements of many existing dams have been measured for some time. In 2014, it was stipulated in the technical standard for river and erosion control engineering to secure seismic records at dams and their foundations as well as data of leakage, uplift, deformation and surface line of seepage. These observation items are minimum requisite

for monitoring dam safety. Additionally, stress gauges, strain gauges, thermometers and others are installed in a dam body and its foundation during its construction for evaluating the dam's behavior and its safety.

Recently, every dam in Japan is in trial for further safety assessment against probable maximum large-scale earthquakes of each site. The technical guideline for this assessment titled "the draft guideline for the verification of dam seismic performance against large-scale earthquakes" was launched by MLIT in 2005.

ii) Check and survey for safety of completed dams

Dam safety monitoring scheme for completed dams consists of 1) daily patrol and check, 2) emergency check, 3) regular inspection, and 4) comprehensive inspection.

The daily patrol and check is conducted by field officials at each dam with visually checking and reading above mentioned data. The emergency check is also carried out by field officials immediate after large-scale earthquakes and other significant disasters. The timing of conducting and reporting the emergency check which composed of quick check, first inspection, and secondary detailed inspection after an earthquake is strictly defined by the ministerial order. The regular inspection shall be done in every three years by an expert team on behalf of field officers at a target dam. The comprehensive inspection is a new scheme for aging infrastructures on over 30 years dams, which is also carried out by an expert team with supervision of academia. According to the result of the regular and comprehensive inspections, the office of managing a dam develops and implements a long-life plan for the dam structure. Monitoring scheme is also reviewed based on this. Of course, rehabilitation is planned and carried out if necessary.

1.6 Case study on earthquake correspondence in Japan

Japan is well known as an earthquake prone country. However, it needs to be clearly mentioned that there is no dam which was designed and constructed in accordance with modern technical standard has collapsed in Japan.

September 1st is designated as the disaster preparedness day in Japan. This is the day of organizing nationwide drill on earthquake correspondence involving most of all organizations such as national government, municipalities, other public entities, schools, hospitals and even private companies, and recalling the lessons learned from the past huge earthquake hit on that day in 1923.

JWA also conducts an overall earthquake drill involving all dam operation and maintenance offices, branch offices and headquarters. Every drill assumes a probable maximum level earthquake has happened and requests immediate and appropriate action to be taken by all level of JWA officials. Before and after each drill, disaster preparedness supplies such as equipment, stored food & water and communication tools are reviewed and upgraded if necessary. Also, drill scenario is revised to make JWA staff exercise more complex judgements and actions.



Photo 1.1 Earthquake disaster drill in JWA

The Case of the Great East Japan Earthquake

At 14:46 on 11th March 2011, the Great East Japan Earthquake hit many JWA dams which received the strong seismic impact requiring emergency checks. One of the 100-meter class high dams of JWA recorded 31 Gals (cm/sec^2) of acceleration at its basement.

Based on the checklists and manuals, JWA staff promptly took action for the quick check and report the result of the check to the JWA headquarters at 14:55 (9 minutes). Subsequently, the first inspection was completed and reported at 17:10 (2h 24 min), and the second check was completed at 20:05(5h 19min).

After this great earthquake, a dam operation office met several times of power failure which was about nine hours in total. At that time, it was hard to get diesel oil and petrol because of damaged supply system. This is a lesson learned to recognize the importance of storing sufficient fuel and equipping backup generators.

The Case of Kumamoto Earthquake in 2016

The strong earthquake, Mw 6.2, occurred at 21:26 on 14th April 2016 in Kumamoto Prefecture in west Japan. The headquarters of JWA immediately opened the emergency operation center following the JWA's disaster management plan. Following pictures show the states of the disaster operation center in the headquarters of JWA after 1 hour from the earthquake.

This earthquake occurred after working hour, but officials in charge of disaster correspondence were automatically mobilized according to the information from mobile phone which was issued by the Meteorological Service Agency (see the photo in the middle). The information from respective JWA field offices was also collected and shared on the white board (see the photo on right hand side). There is no doubt that preparation of checklists and manuals and continuous drills enable this swift response.



Photo 1.2 Emergency Operation Center in JWA

2. Scope of Work

2.1 Objective

The primary objective of developing the inspection manual is to review the operations and maintenance methods at a dam site, monitor procedures and status of Maithon Dam (managed by Damodar Valley Corporation) under Dam Rehabilitation and Improvement Project, and to provide advice and guidance to improve the O&M methods from dam safety points of view. More specifically, the manual will provide guidance on providing operation and maintenance methods during/after the seismic activities, and will draft manuals and checklists of the activities needed to be performed after the seismic activities from the dam safety view points for field engineers under DRIP. Mock drill exercise will be conducted at Maithon dam site to go through the draft checklist and manuals with the DVC counterparts before finalization of the output.

Moreover, technical advices for establishing telecommunication system on observed seismic information will be provided with reference to the existing system, which may clarify design requirements to be considered before system development. A conceptual schematic diagram of the telecommunication system to be applied to Maithon dam in case of the seismic event will also be prepared.

2.2 Project Site

This work shall be deemed as the second phase of earthquake resilience improvement. For the first phase in 2016, Ichari Dam in Uttarakhand State was selected by WB and Central Water Commission (hereafter CWC) taking into account applicability and eligibility for the first attempt of earthquake emergency response and also linkage with DRIP. Ichari Dam is a concrete gravity dam.

Same as the first phase, Maithon Dam in Jharkhand State was selected by WB and CWC in advance. Maithon Dam is a composite dam, consisting of concrete gravity dam and embankment dam. Figure 2 shows the location of Maithon Dam.

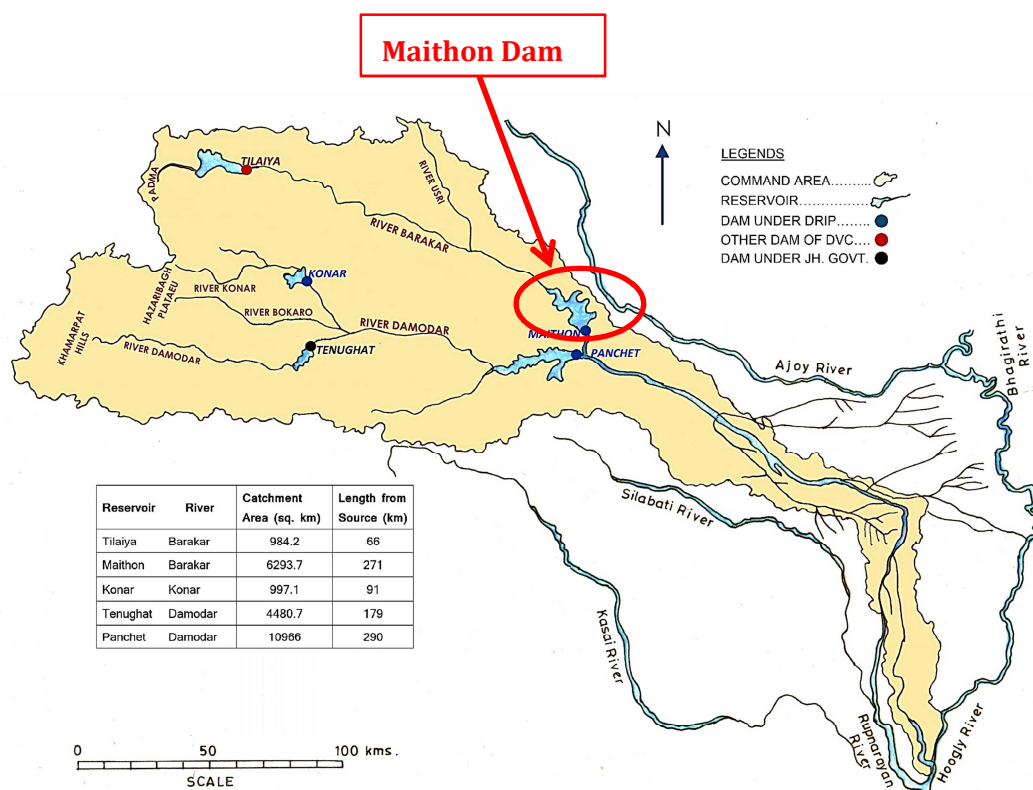
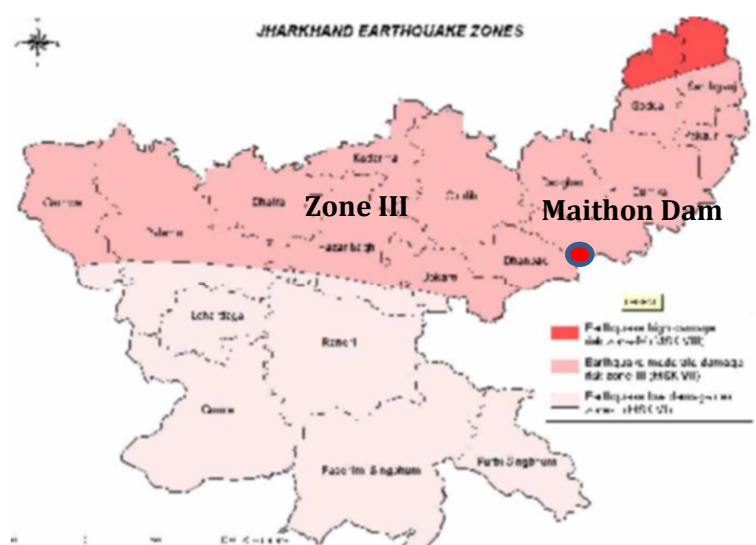


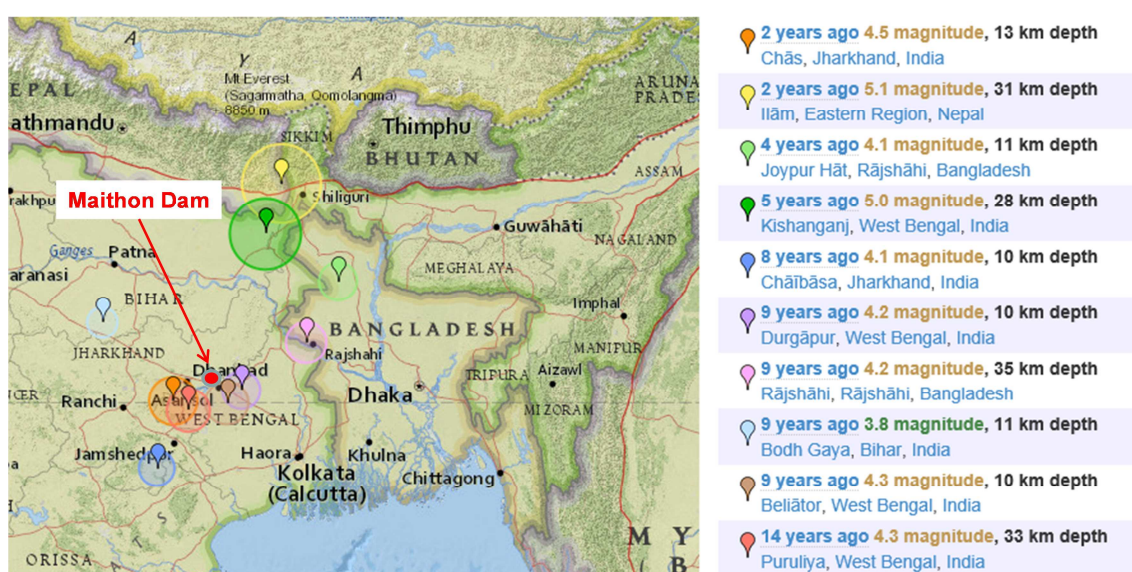
Figure 2.1 Location of Maithon Dam

Maithon Dam (Length: 4,426.7m, Height: 56.08, completed: 1957) is owned by Damodar Valley Corporation. This dam is located on Barakar river which is a tributary of Damodar river and has a drainage area of 6,293.7km². The altitude of the dam crest is EL.156.06m, while the foundation level is EL.99.98m. The Dam is located in potential earthquake area categorized into zone 3. Figure 2.3 shows the recent earthquakes that have occurred near Jharkhand State. Fortunately, no disaster caused by the earthquakes was reported, however it is obvious that Maithon Dam is under the high risk of strong earthquakes.



(Source: NIDM, Jharkhand, National Disaster Risk Reduction Portal)

Figure 2.2 Jharkhand Earthquake Zone Map



<http://earthquaketrack.com/p/india/jharkhand/recent>

Figure 2.3 Recent Earthquakes near Jharkhand

2.3 Approach and Methodology

- i) A field survey and a workshop at the target dam to develop the draft earthquake emergency inspection checklists

As a first step, JWA team visited the project site and investigated the technical features

of Maithon Dam in the 1st mission in July 2017. Following to site visit, JWA conducted a workshop with field engineers to introduce earthquake emergency response scheme practiced in JWA dams in Japan. In accordance with the instructions of JWA regarding the dam safety guidelines on inspection and its evaluation, JWA team outlined the procedures to draft emergency inspection manuals and checklists. The participating field engineers developed the tailored checklists for Maithon Dam through the group discussions. Maithon Dam and the entire checklists are attached in Annex 1.

ii) The draft of earthquake emergency inspection manuals & checklists

Based on the developed checklists, JWA will prepare the draft emergency inspection manuals for Maithon Dam and the mock drill scenario before the second mission, November 2017. Through the development of scenario, current deficiencies and tentative alternatives for emergency response could be clarified. Also, some subjects to be improved in the future would be emerged.

The interim report is to be submitted after the process of i) and ii).

iii) A field drill and the revision of manuals & checklists

The mock drill for the emergency response against an earthquake will be conducted at Maithon dam in the third mission, January 2018. The drill aims at deepening understanding of earthquake response and use of the manuals and checklists. Also, the feedback after executing a drill will be incorporated into the next version of manuals and checklists.

JWA team will continuously support the drafting work before the mock drill and developing the drill scenario.

iv) Others

Technical advices for establishing telecommunication system on observed seismic information will be provided with reference to existing system, which may clarify design requirements to be considered before system development.

In general, a concrete gravity dam is required to monitor its deformation, leakage, and uplift as very basic check items for proving its safety. In the case of an embankment type dam, its seepage, deformation and saturated line are corresponding to this

thought.

For all the check items, frequency of monitoring depends upon stability of a dam. If the dam seems quite stable, observing every month would be sufficient. Once some change in the observed data has happened, monitoring frequency should be reviewed to be changed to every week or day.

In addition to these basic monitoring items, a seismometer at the dam site will help to monitor external force to affect the dam. It can provide a trigger for emergency actions to be taken by engineers.

Maithon dam is a 60-year old dam but looks healthy. Currently, major rehabilitation work is in process, which will be repairing and repainting old gates with exchange of some parts and developing remote controlling systems. However, most of above mentioned items to be inspected are not continuously monitored. During the planning drill, JWA and DVC members will discuss how to set the emergency check items and recommend what kind of instrumentations should be installed in the future.

2.4 Concept of Earthquake Emergency Inspection

The manuals and checklists will be developed based on the JWA's practices and discussions with CWC and relevant persons/organizations. In the case of JWA, earthquake disaster management is graded in accordance with observed seismic intensity or acceleration at the facilities and specific inspections to be conducted after a significant shock are regulated in the chronological order (see Figure 2.4). The checklists for each inspection are prepared respectively and immediately reported to higher authority.

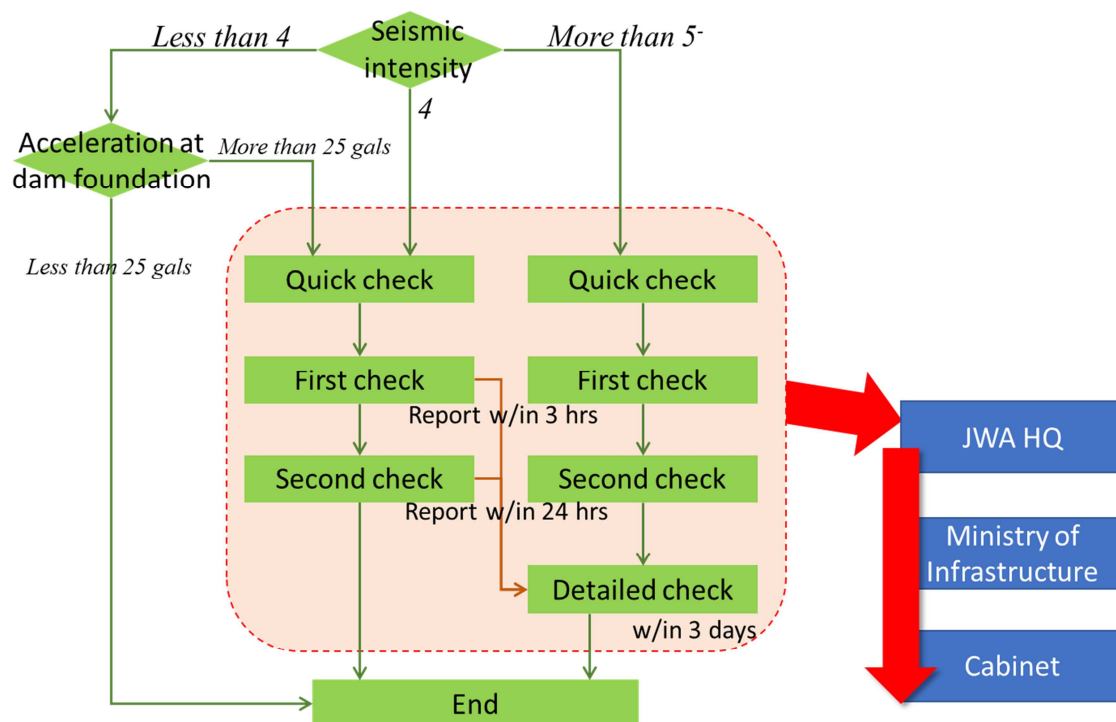


Figure 2.4 Outline of JWA Earthquake Disaster Management

3. Work Plan

3.1 Timeframe

See the next page.

Work Schedule

Table 3.1 Work schedule

N°	Activity	Months											
		Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	
1	Preparation	<div><div></div><div></div></div>											
2	1 st mission (Checklists)		<div><div></div><div></div></div>										
3	Inception report			<div><div></div><div></div></div>									
4	2 nd mission (Manuals & drill scenario)						<div><div></div><div></div></div>						
5	Interim report							<div><div></div><div></div></div>	<div><div></div><div></div></div>				
6	3 rd mission (Drill)								<div><div></div><div></div></div>	<div><div></div><div></div></div>			
7	Final report										<div><div></div><div></div></div>	<div><div></div><div></div></div>	

3.2 Team Composition

Table 3.2 Member of Implementation Team

Tatsuo Kunieda	Team Leader
Yoshihiro Yamashita	Sub Leader
Kazumi Sasaki	Expert for dam safety
Masahiro Sugiura	Expert for electric, information and communication system
Tomonobu Sato	Expert for mechanical facilities

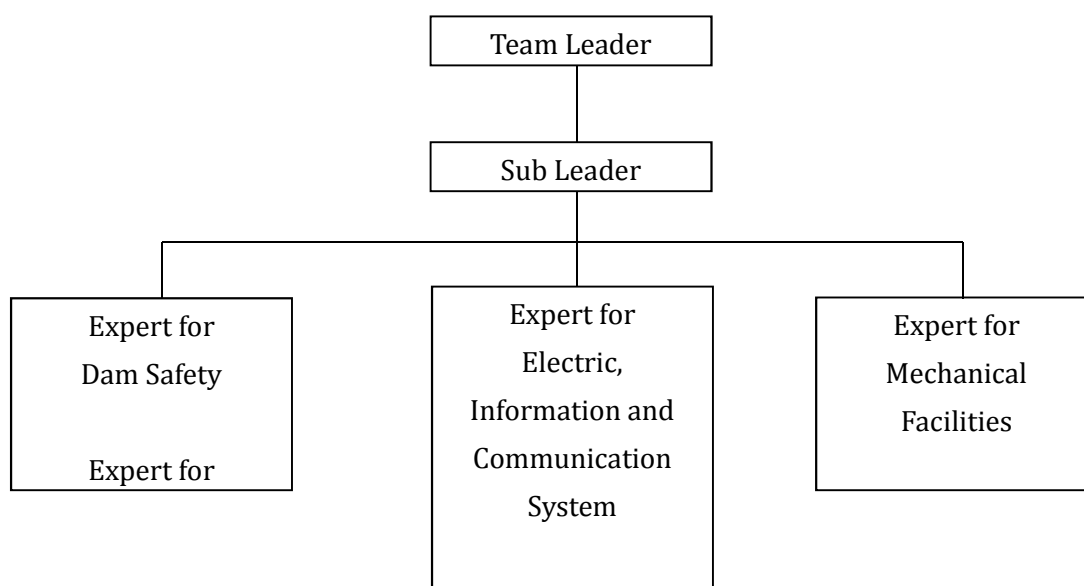


Figure 3.1 Organization of the implementation team

4. Counterpart Agencies

4.1 Central Water Commission, Ministry of Water Resources River Development & Ganga Rejuvenation

Central Water Commission or CWC in India is the Apex body in the field of water resources, working under Ministry of Water Resources, River Development & Ganga Rejuvenation, and the Government of India. The commission is entrusted with the general responsibilities of initiating, coordinating and furthering schemes for control, conservation and utilization of water resources throughout the country in consultation with state governments concerned for the purpose of flood control, irrigation, navigation, drinking

water supply, and hydropower development.

Since 2010, CWC has been taking a leadership of the management of DRIP. The target dam candidates were selected from the dams of DRIP as a result of discussions among DRIP members. For these services, CWC will collaborate with Japan Water Agency to apply the result of this consultation service for other dams in DRIP.

4.2 Damodar Valley Corporation

Damodar Valley Corporation or DVC owns and manages 5 dams (Tilaiya, Maithon, Konar, Tenughat and Panchet) and has been supplying electric power and irrigation water and controlling flood in accordance with the provision of the DVC Act in 1948.

DVC and CWC discussed and finally selected Maithon dam as the target dam. It is expected that DVC will proactively cooperate with JWA for successful implementation of the services. DVC thoughtfully selected participants for the workshop from their field engineers. DVC will also consider the application of the manuals and checklists to other DVC's dams.

4.3 Counterpart's Inputs

i) Staff

CWC and DVC need to identify a nodal officer who will work alongside with the team from JWA and will support conducting the site visit, data and information collection, and coordination with other staff members and relevant organizations.

ii) Equipment and Logistics

- For the sake of convenience, the venue for the consultation meeting will be set at a meeting room in the target dam office.
- Personal computers for group discussions are expected to be provided by a counterpart organization. At least, three pieces of PCs are needed in which Microsoft "Excel", "Word" and "Power Point" or equivalent software are to be installed in advance.
- The operation room adjacent to the dam body and related facilities should be available for the field survey and the drill.
- A printer (A4) is required for printing out the minutes and/or memos of the discussions and other related meetings. And a projector is also required.

- Arrangement for local accommodations and vehicles for site visits are to be arranged by DVC.

5. Project progress

5.1 1st Mission

The 1st mission aimed;

- to build consensus on and preparation of checklists and manuals for emergency inspection,
- to review the existing systems with regard to the dam and reservoir management, and
- to collect relevant information and materials for developing manuals

The mission itinerary is shown on Table 5.1. The aiming result of the consultation meeting and the findings of field survey were reported by JWA and tentative plan of future activities was confirmed. All the presentation materials are attached in the Appendix 1.

Table 5.1 1st Mission Itinerary

3 rd July, Mon	18:10	depart from NRT to DEL	Stay at DEL
4 th , Tue	13:00	Meeting with CWC	Stay at CCU
	17:45	depart from DEL to CCU	
5 th , Wed	13:30	Preparatory meeting with DVC	Stay at CCU
6 th , Thr	9:00 - 13:00	Move to Maithon dam by a vehicle	Stay at Dhanbad
	13:00	Preparatory meeting and survey at Maithon dam	
7 th , Fri	9:00-12:00	Workshop for drafting checklists and manuals	Stay at Dhanbad
	13:00-15:00	Field survey at Maithon dam	
8 th , Sat	9:00 – 13:00	Move to CCU	Stay at CCU
		<i>Surveying downstream reach of Maithon dam on the way</i>	
9 th , Sun		Documentation	Stay at CCU
10 th , Mon	9:30	Meeting with DVC head office members	Stay at DEL
	18:00	depart from CCU to DEL	
11 th , Tue	14:00	Wrap up with CWC	
	25:15	depart from DEL	
12 th , Wed	13:00	arrive at NRT	

5.2 2nd Mission

The 2nd missions aimed at discussing on the manuals which were drafted based on the checklists in the 1st missions and collecting further information and materials in the field.

Due to significant delay of scheduled flight, it was forced to change itinerary. However, the objective of this mission was mostly accomplished.

Table 5.2 2nd Mission Itinerary

13 th Nov (Mon)	13:05 Departure from Tokyo (HND)	
14 th (Tue)	15:30 Arrival at Kolkata	Stay at CCU
15 th (Wed)	09:00 Depart from Kolkata 14:00 <u>Field survey at Maithon Dam</u>	Stay at Dhanbad
16 th (Thu)	09:00 Depart from Dhanbad 10:00 <u>Field survey at Maithon Dam</u> 13:00 <u>Wrap up</u> 20:00 Arrival at Kolkata	Stay at CCU
17 th (Fri)	08:00 Departure from CCU	
18 th (Sat)	06:15 Arrival at Tokyo (NRT)	

5.3 3rd Mission

The 3rd mission aimed to conduct a mock drill in accordance with a drill scenario which was confirmed between JWA and DVC in the preparation meetings.

The roles of each DVC officers in an emergency response and respective actions were clarified.

Table 5.3 3rd Mission Itinerary

10 th March (Sat)	Departure from NRT	
11 th (Sun)	Arrival at Kolkata	Stay at CCU
12 th (Mon)	8:30 Depart for Maithon Dam 14:30 Meeting with DVC members - Confirming drill scenario and arrangement	Stay at Dhanbad
13 th (Tue)	10:00 Re-confirmation of detailed scenario	Stay at Dhanbad
14 th (Wed)	07:30 Depart from Hotel 10:00 Field drill 12:00 Feedback meeting (Maithon Dam) 15:00 Depart for Kolkata	Stay at CCU
15 th (Thu)	10:55 Depart from Kolkata 13:30 Arrive at Delhi 16:00 Meeting with WB 25:15 Depart from Delhi	
16 th (Fri)	13:00 Arrive at NRT	

5.4 Field survey on Maithon Dam

The outline of Maithon Dam is as follows:



Photo 5.1 Maithon Dam

Table 5.4 Salient Features of Maithon Dam

Type of scheme	Storage type
Catchment	6,293.7 km ²
Gross storage	736.4 million m ³
Dam type	Composite; Concrete gravity and Earthen
Height	56 m
Length	4,426 m
Spillway	Gated, 12 nos. radial gates
Design flood	14,727 m ³ /s
Spillway gates	Height 12.5 m × width 12.5m
Other facilities	Under sluices (Vertical Lift 5 Nos. 1.7m × 3.0m, spillway gantry crane, dewatering pumps

Major findings in the field survey are as follows;



Down side of concrete gravity portion of Maithon Dam: surface of concrete seems to be in healthy condition despite 60 years old since its completion. Due to low water level, leakage from the gate was not observed, but some from sluice gates.



Upstream side of Maithon Dam.
12 spillway gates on the top



Under renovation of riprap financed by DRIP.



Intake tower for power generation which is one of the key assets for managing the dam.



Parapet wall on left side earth dam: if sever deformation such as significant settlement or slope failure would happen; some change could be observed in this view.



Saddle dam on left bank; the downstream slope is mostly covered with vegetation. It was recognized by DVC that cutting and clearing vegetation is necessary for appropriate maintenance. However, consultation with the forest authority is required to build the consensus.



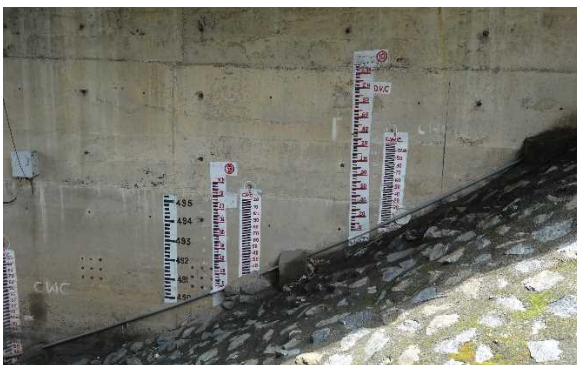
Inspection gallery in the bottom of gravity dam. Although there is no monitoring system, only limited leakage is visually observed even at the high reservoir water level. Drain holes along the gallery were well maintained.



Gate opening meter



Switch box for gate operation at field



There are two water level gauge system which are managed by DVC and CWC respectively. Pressure type automatic water level gauge is also installed by CWC.



Together with water level, precipitation is also observed by and sent to CWC in Delhi.



Meeting with DVC engineers, 1st mission, July 2017

Concept of earthquake response was shared and checklists for emergency inspection were developed in this workshop.

Photo 5.2 Major Findings in the Field Survey and Meeting with DVC Engineers

6. Process for Maithon Dam emergency inspection

6.1 Background and Objective

A dam with massive water storage is a structure which requires to be treated with caution especially when a significant earthquake occurs. Avoiding or minimizing any human and economic damages in lower reach is a race against time. In order to collect and disseminate necessary information about damage of the dam immediately and appropriately and make a decision for subsequent actions, it is essential to establish some scheme to work systematically.

In Japan, it is an obligatory process for the field engineers working at a dam operation office to be automatically assembled for carrying out a prompt dam safety inspection immediately after a significant earthquake event. The inspection results must be reported to the national government on a timely basis. The inspection consists of three phases namely the quick check, the first inspection and the second inspection.

JWA developed and repeatedly upgraded its original manuals of these inspections in order to conduct the inspections without omission even by inexperienced engineers. Using this experience, Maithon dam managed by DVC in India was selected to be a second pilot site to install this dam emergency inspection system subsequent to Ichari Dam last year.

6.2 Framework of emergency inspection for Maithon Dam

The trigger for starting the sequence of earthquake correspondence is tentatively defined as following two thresholds. The first one is 25 gals of acceleration observed at the bottom of a dam. A seismometer has not yet been installed at Maithon Dam, but the drill will be conducted assuming that it is available. The second one is the information from Indian Meteorological Department (IMD). If the epicenter is less than 100 km from Maithon Dam and estimated magnitude is over 6.0, the earthquake correspondence shall be immediately started.

Relating to this topic, the Bulletin #166 of ICOLD (International Commission of Large Dams) titled “Inspection of Dams following earthquake guidelines” describes on the necessity of an immediate inspection following earthquake. In this document, the trigger for this action is defined a Richter magnitude and radial distance. (see the BOX)

[BOX]

INSPECTION OF DAMS following earthquake guidelines, ICOLD (Excerpt)

3. IMMEDIATE INSPECTION FOLLOWING EARTHQUAKE

3.1. WHEN COMMUNICATION LINKS ARE IN PLACE

If an earthquake is observed at or near a dam, or one has been reported to have occurred, with a Richter magnitude greater than and within a radial distance as set out in the table below, follow these procedures:

Magnitude	Distance (km)
>4.0	25
>5.0	50
>6.0	80
>7.0	125
>8.0	200

Note these combinations have been chosen such that a significant intensity level is expected to have been experienced at the dam site. An alternative trigger for inspection could for example be an intensity of shaking of greater than MMI 4 experienced at a dam site.

Having said that, it should be noted that the most important parameter for dam safety is strength of quake at (or very near) the dam site. The second trigger does not directly represent this point and takes some time before getting information. In this context, it is expected that the triggers mentioned above would be reviewed in accordance with availability of earthquake information.

The overall framework of the emergency inspection is shown in Figure 6.1. The emergency inspection was narrowed down to the quick check and the first inspection as a result of the workshop. The secondary inspection was excluded from the emergency inspection of Maithon Dam since it can be replaced to the normal daily check. The time line of reporting was adjusted in the context of India which was based on the discussion result of the workshop. The result of quick check shall be reported within 2 hours and the first inspection shall be within 5 hours. These reporting timelines are consistent with those of Ichari Dam last year.

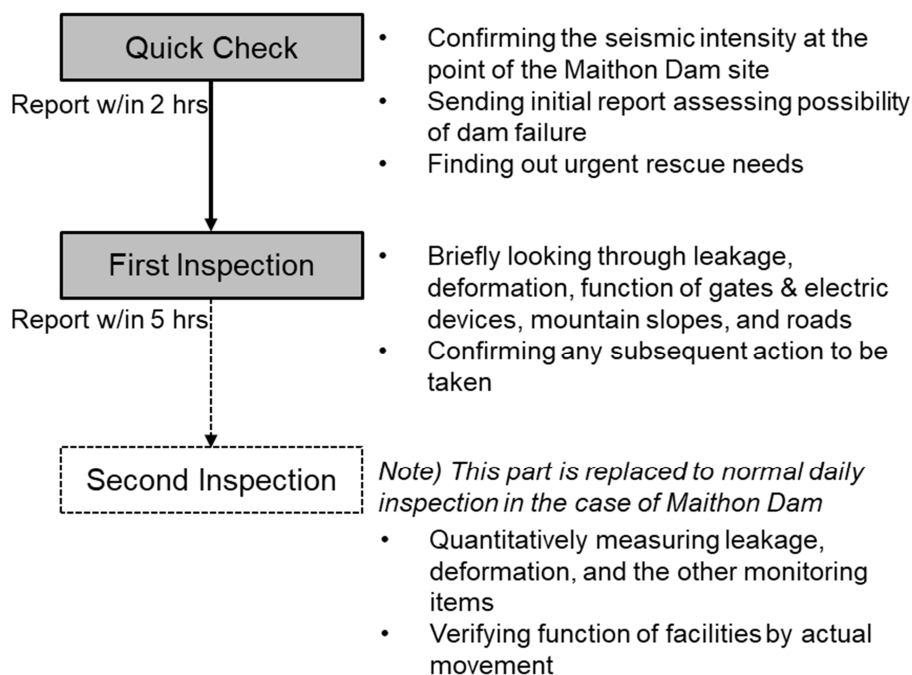


Figure 6.1 Framework of the emergency inspection of Maithon Dam

In the consultation meeting in the 1st mission, JWA team presented the process of the emergency inspection aftermath of an earthquake, and the information flow was established, and the checklists were drafted in collaboration with the participants. Figure 6.2 shows the revised information flow after the 2nd mission.

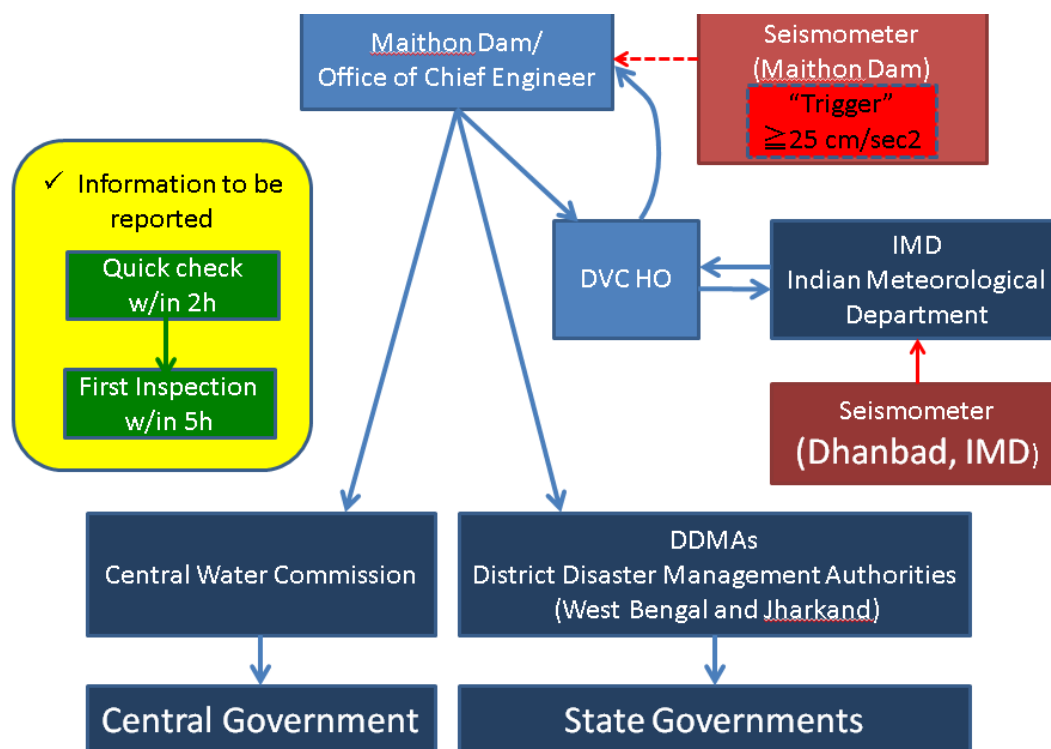


Figure 6.2 Information Flow for Earthquake Correspondence in the case of Maithon Dam

As already mentioned, it is effective to prepare the checklists and relevant manuals for emergency inspection in order to implement lots of checks without any hesitation and redundancy immediate after a significant earthquake. A checklist should contain minimum but sufficient check items according to its objective. An earthquake drill is also an effective way for all the officials concerned to be accustomed to the checklists and the manuals, and to get realistic feedback. By doing this, the capacity of related officials will be enhanced, and disaster reaction will become more resilient.

One of the common principles in an earthquake emergency situation is not to use an elevator. In order to avoid any secondary trouble such as locking some officials in by an aftershock, all the inspections should be carried out without using any elevator. In the case of Maithon Dam, an elevator does not exist.

6.3 Implementation modality

i) Maithon Dam and Damodar Valley Corporation

For responsible and prompt work, implementation modality in an emergency case should be simple. In general, field officers will report the check result to the head of the dam management office who will report to the top management in the head office. An executive officer in the head office will be responsible for reporting it to the relevant agencies.

In the case of Maithon Dam, the modality will be in a bit irregular style since most of key engineers including executive engineers stay in the administration building located near the dam and they look after not only Maithon dam but also the other dams in the Damodar river; Tilaiya, Konar and Panchet. Their residences are also located very near the dam. Given this advantage, the implementation modality for emergency response of Maithon Dam is determined as Figure 6.3 which is called the Disaster Management Headquarters of Maithon Dam. In principle, the officials in the administration building will be responsible for all communication on the dams and the role of head office in Kolkata will be limited in this early inspection stage.

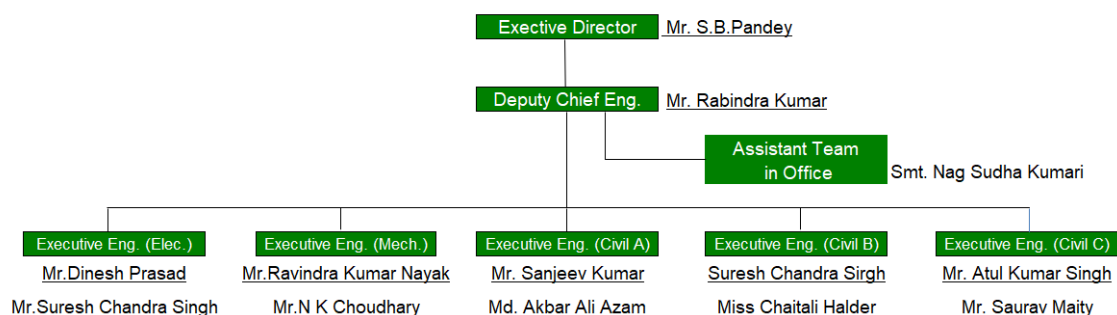


Figure 6.3 Disaster Management Headquarters of Maithon Dam

ii) Central Water Commission

Central Water Commission (CWC) shall integrate all the information on the state of dams in India. If any urgent issues were emerged, CWC will work with related agencies to minimize any negative impacts. After emergency phase, CWC will review the disaster management carried out and update systems required. Currently, CWC is in charge of establishment of Emergency Action Plan (EAP) for DRIP members.

iii) District Disaster Management Authority

A District Disaster Management Authority (DDMA) primarily supports life of general public from disaster management perspective. Since it is important to protect people in the downstream of a dam from any disaster, the DDMA is involved in the information flow as a counterpart agency. Maithon Dam and its reservoir are located over two states; Jharkhand and West Bengal, so the DDMA's of both states will be involved in this scheme.

6.4 Quick Check

i) Objective

The objective of "Quick Check" is to confirm received seismic intensity and obvious damage that leads to dam failure as soon as possible. However, it should be noted that the quick check aims only at looking over the possibility of immediate dam failure, and the mid or long-term safety of dam body can be confirmed through the first inspection and subsequent normal daily check.

ii) Checklists

The checklist mainly consists of checking seismic intensity observed at Maithon Dam and external visual checks. It needs to be noted that there is no seismometer placed at Maithon Dam currently, but it is anticipated that DVC would plan to install it soon.

The following points shall mainly be checked very quickly by judging from appearances.

- ✓ External appearance of the dam body: Stability and water tightness of the dam body are cores of dam safety. Any noticeable deformation, leakage from dam body and boundary between the dam and its foundation shall be quickly checked visually.
- ✓ The reservoir and surrounding slopes: A serious earthquake occasionally leads to landslides which would lead to flood wave propagation and creation of natural unstable dam. It is important to find difference between the slope situation before and after the earthquake. In the case of Maithon Dam, there is no such a steep slope around the reservoir, so it is not included this time.
- ✓ Gates and turbines: Any distinct change on leakage from the gates and any abnormal sound or smell from the turbine should be checked.

iii) Manual

The manual was developed in consideration with the following points.

- The traffic line for the officials of Maithon Dam is sketched in the manual. By following this line, he/she can check perfectly in very short time.
- There is no facsimile installed in Maithon Dam operation office. The result of the quick check shall be sent by e-mail.

The Checklist and Manual are attached in Appendix 2.

6.5 First Inspection

i) Objective

The aim of the first inspection is to confirm the functionality and safety of Maithon dam. If some issues were found, there would be possibility to change operation of the dams such as urgent shut down of the generator. If worse, supplemental staff should be urgently sent from the head office or CWC.

In order to meet the above objective, the field engineers need to check structures such as the dam, roads, and intake, mechanical facilities such as gates, valves and electrical and telecommunication systems.

ii) Checklists and Manuals

The checklists and manuals are prepared in three parts namely for civil engineering structure, mechanical facilities, and electric & telecommunication facilities.

Civil Engineering Structures

➤ Checklist

In general, deformation, change of leakage and uplift from base rock shall be listed as check items and monitoring systems for these should be appropriately installed and maintained. In the case of Maithon Dam, only the change of leakage can be measured for the time being.

Therefore, the checklist mainly consists of measurement of leakage at the bottom of inspection gallery, and visual external inspection of downstream surface of the dam and of boundary zone between the dam body and the rock foundation.

➤ **Manual**

Same as the quick check manual, the traffic of the field engineers is illustrated in the manual taking into account the following points, which will facilitate a smooth and secured inspection to be conducted.

- Indicating fixed positions and directions in regular checks to observe changes of the dam and the others from the regular positions,
- Delineating places to be checked,
- Listing requisite tools for appropriate preparation of inspection,
- Describing as short as possible for easy understanding, and
- Using very simple words for those who do not have expertise.

Mechanical facilities

The major objective of the manual for mechanical facilities is to confirm the operability of the gates and valves for flood control and water supply.

➤ **Checklist**

The major check items in the checklist are the gate system and the drain pump.

- ✓ The check items on the gate system covers strain of gates, kink of wire ropes, and function of the system by testing the local operation boards. (After installation of remote operating board, the gate system should be checked by remote operating boards also).
- ✓ The drain pumps located at the bottom of the inspection gallery should be checked to avoid inundation by water leakage.
- ✓ In case of additional emergency inspections or any rescue, the condition of the inspection boat should be checked.

➤ **Manual**

Maithon Dam equips a lot of gates and mechanical facilities involving twelve spill way gates, hydropower plant, and intake gates. The track lines for checking in order are drawn in the manual for time efficient and accurate inspections.

Electric and Telecommunication devices

The main objective of the checks on electric and telecommunication devices (E&T) is to secure power supply for dam operation and communication line between Maithon Dam and related entities.

➤ **Checklist**

The following items shall be checked with the checklist.

- ✓ Regarding the power supply, both access & transformation equipment, and the emergency generator shall be checked. The emergency generator shall be confirmed its operation.
- ✓ Telecommunication system is composed of only a commercial line except a few exclusive lines which are used in very limited place. In an emergency case, the mobile phone is normally used for the communication between the field engineers and head office of DVC.
- ✓ The status of the monitor of operation panel. (After installation of SCADA and CCTV, the status should be checked by SCADA and CCTV also).

➤ **Manual**

The manual for E&T shows the track line for the officials to make a prompt check, same as the manual for civil engineering structures and the mechanical facilities.

(After installation of SCADA and CCTV, some examples of the display on the operation panels and CCTV systems could be shown on the manual.)

The Checklist and Manual are attached in Appendix 3.

7. Field Drill

7.1 Objective

Using the developed checklists and manuals, the field drill for Maithon Dam was conducted by DVC with support from JWA team. The objective of this drill was to make all officials concerned familiarize the correspondence to earthquakes and to verify the applicability of the developed checklists and manuals which will be revised in accordance with KAIZEN¹ approach.

7.2 Scenario

The scenario is a kind of timeline consisted of required actions to be carried out by the officials concerned after the significant earthquake. This time, the scenario assumed that an earthquake of M7.4 at the Dargapur would occur on 10a.m. and 150 gal (cm/sec²) of acceleration would be observed at the bottom of dam. The assumed earthquake was set with reference to the historical earthquakes near Maithon Dam.

The scenario was drafted by JWA and finalized through discussions with DVC. In the discussion, responsibilities and roles of related organizations and every official were clarified. In fact, this process is one of the cores for establishing firm and active emergency response system. The detailed scenario is attached in Appendix 4 and outline is presented in Figure 7.1. The relation between the drill and the EAP which had been already developed in the DRIP was clearly drawn in this figure.



Photo 7.1 Meeting at Maithon Dam

¹ KAIZEN in Japanese means continuous improvement. It is recognized worldwide as an important pillar of an organization's long-term competitive strategy.

Participants of this drill were officials of Maithon Dam and persons in charge of emergency response in DVC head office, in CWC and in related organizations. It would be effective that the officials who actually work in the case of real earthquake will be involved in the drill.

The scenario can be divided into three phases; “initial communication immediate after the strong quake”, “Quick check and reporting” and “First inspection and reporting”. Additionally, the scenario contained the emergency responses against damages such as increasing leakage from a drain hall and damages on the parapet wall on the top of the dam etc. These actions and collected information shall be linked with the EAP.

At the time of the field drill, the seismometer had not yet been installed. However, the scenario was developed assuming a seismometer had already been installed and functional.

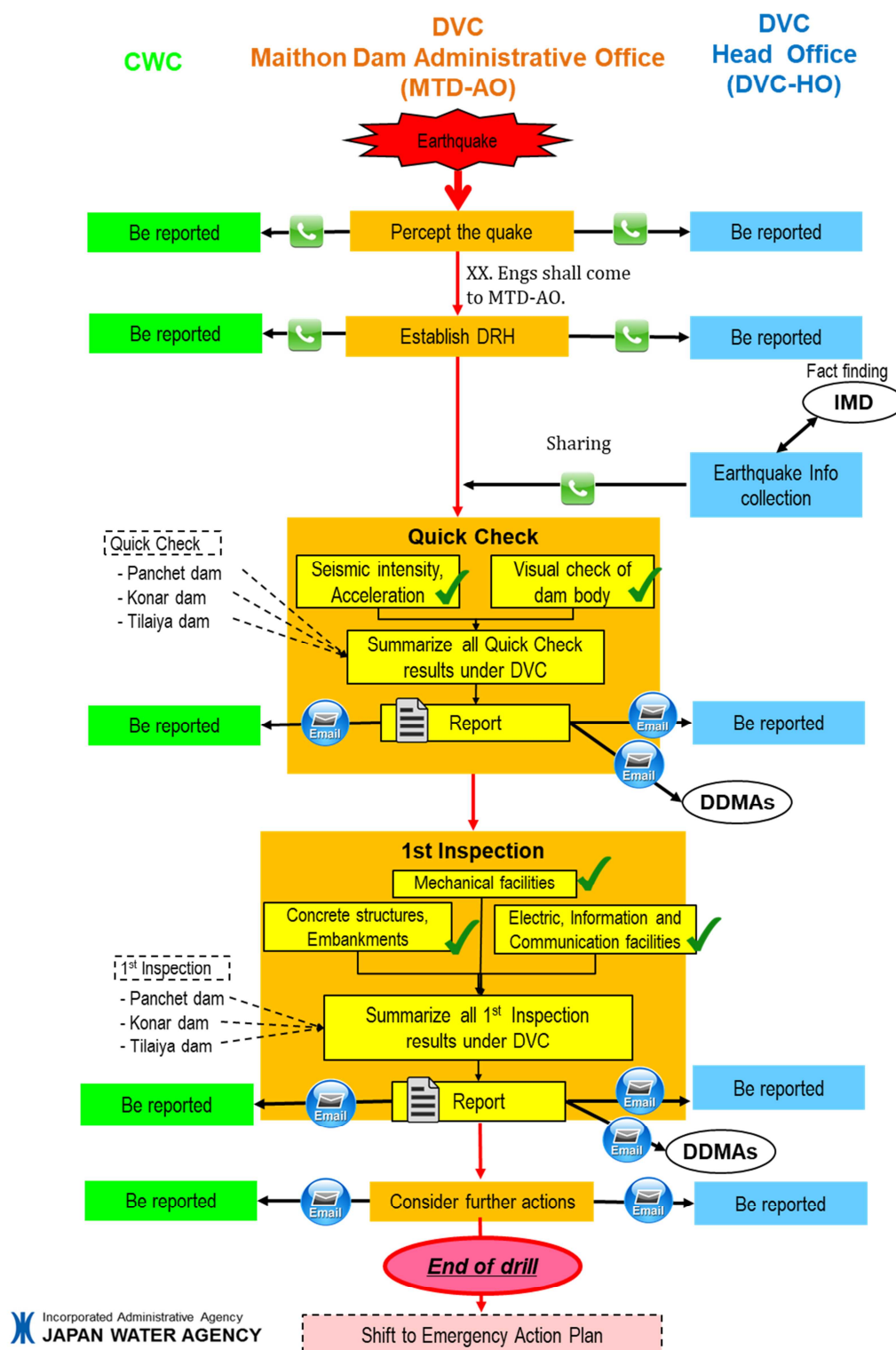


Figure 7.1 Drill flow

7.3 Field drill

At the day of the field drill, not only drill participants but also many stakeholders such as CWC, IMD, DDMA, UJV, Tamilnadu were invited to observe the drill. All the participants and observers gathered at the shading tent which was temporally pitched on the left-top of Maithon Dam. This shading tent was regarded as the control room which actually exists in the administrative building 700m away from the tent.



Photo 7.2 Participants and Observers at the Shading Tent

The drill was started by the JWA's announcement which informed perception of a quake. Then, the executive engineer at his house was informed from a Jr. engineer of Maithon Dam. After communicating with persons concerned, he headed to the dam around 1km far from his house. As already mentioned, in the drill this time, all the participants are under the tent and played the role of each person. The observers who have no information in advance were able to monitor and understand all the emergency process after an earthquake. However, some of real situation such as telecommunication and actual transference were not able to be replicated due to locational constraints. Also, some parts of the inspection processes needed to be skipped due to time constraints. It is expected that these would be addressed in the next drill.

The followings are the photos from the drill.



Photo 7.3 Initial Communication (Roll Playing)

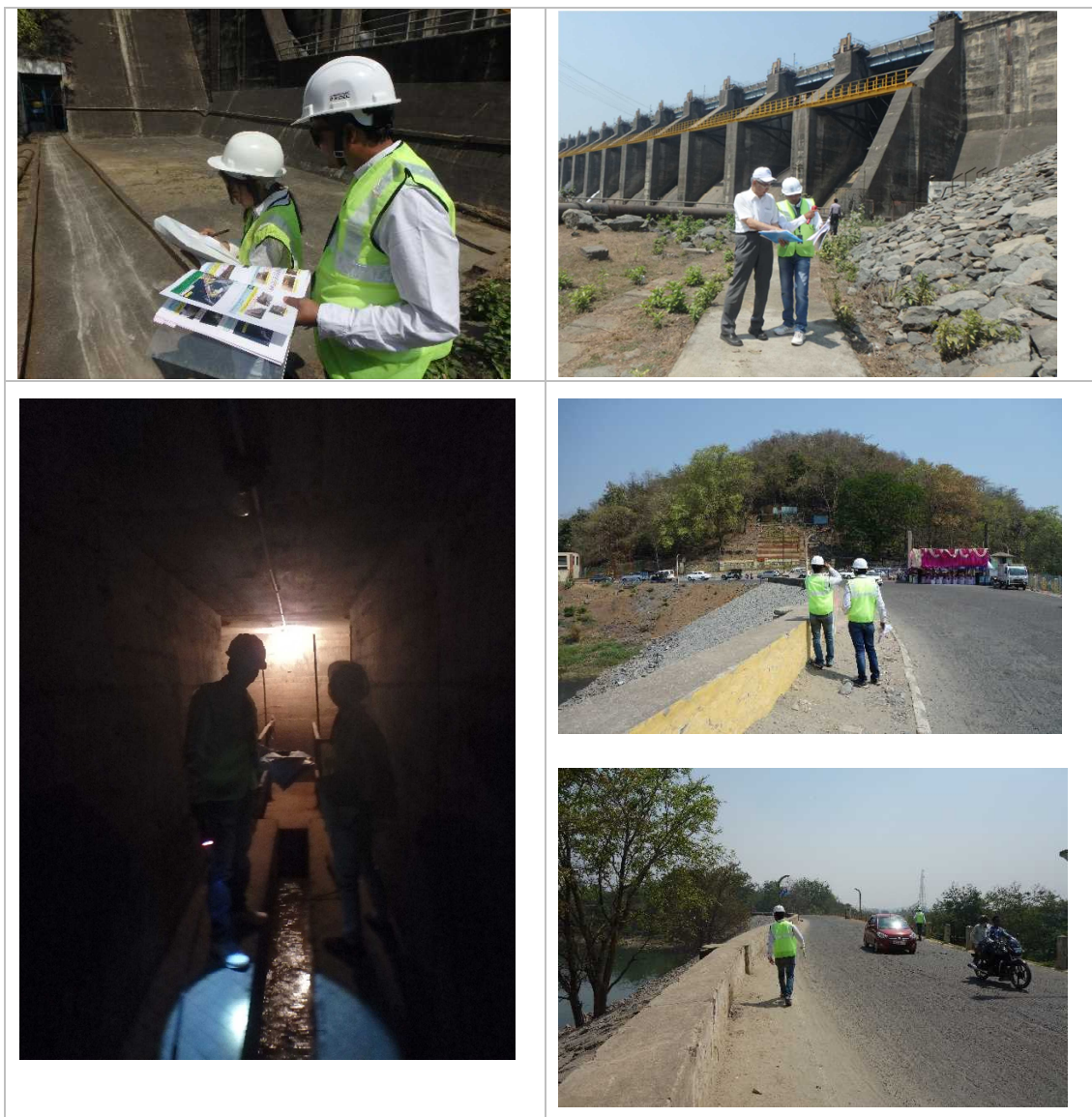




Photo 7.4 1st Inspection (Civil Engineering)

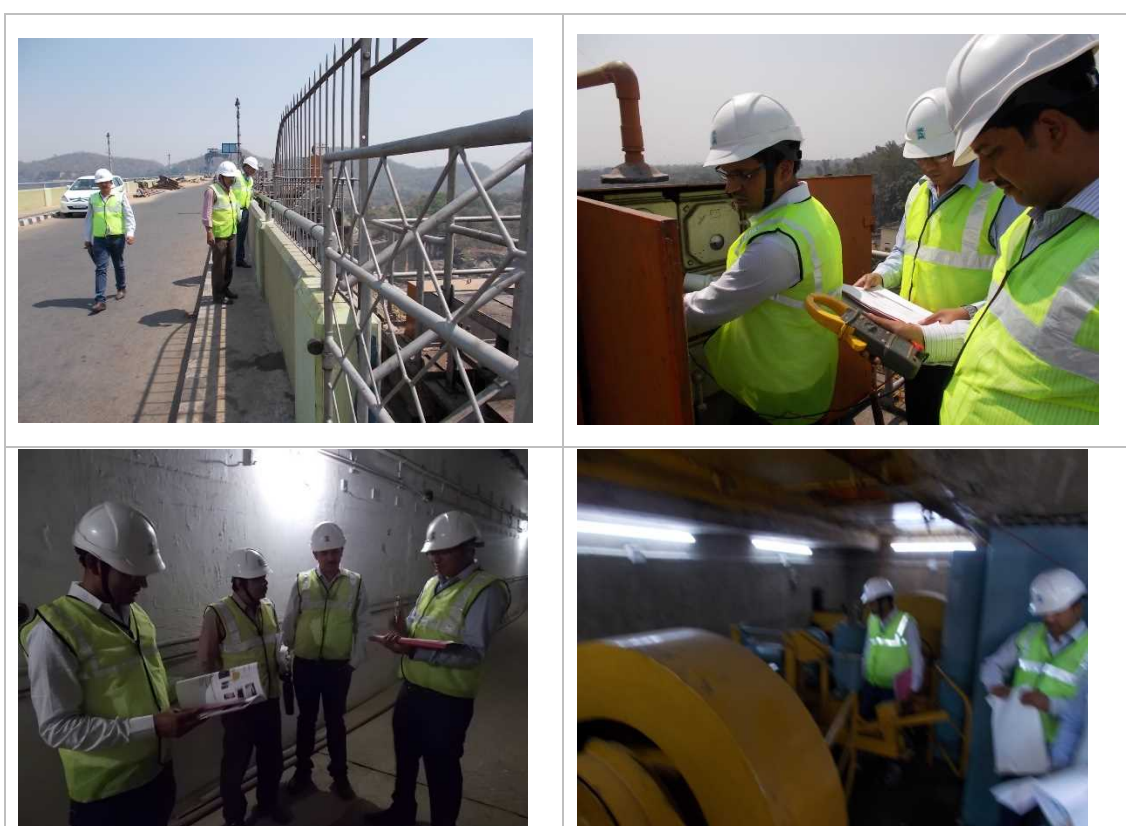


Photo 7.5 1st Inspection (Electric and Machine Engineering)



Photo 7.6 Reporting to the Disaster Management Headquarters

7.4 Feedback Meeting

After the field drill, a feedback meeting was held at the same place to get feedbacks from the drill and to find points to be improved for the next time. A lot of positive and constructive comments were provided by the participants, which are summarized as below.

- IMD has developed an earthquake app which can inform you when an earthquake occurs.
- This mock drill is fine as initial attempt. The next drill should be carried out with more real situation using the telecommunication.
- The idea is clear that the post drill inspection is very essential for the Dam structure
- Another thing needed to be care of is downstream loss which is not concerned in this drill.
- More checklists can be added in the detailed inspections.
- Manuals and Checklists may be available in company website and can be access by authentic authorities
- Maithon Dam is not located in a severe earthquake zone, thus such mock drill may be done on the dams where such earthquakes happened.
- Manuals can be more customized & updated with time.
- It is needed to continue the same specially on real incidents.



Photo 7.7 Feedback Meeting

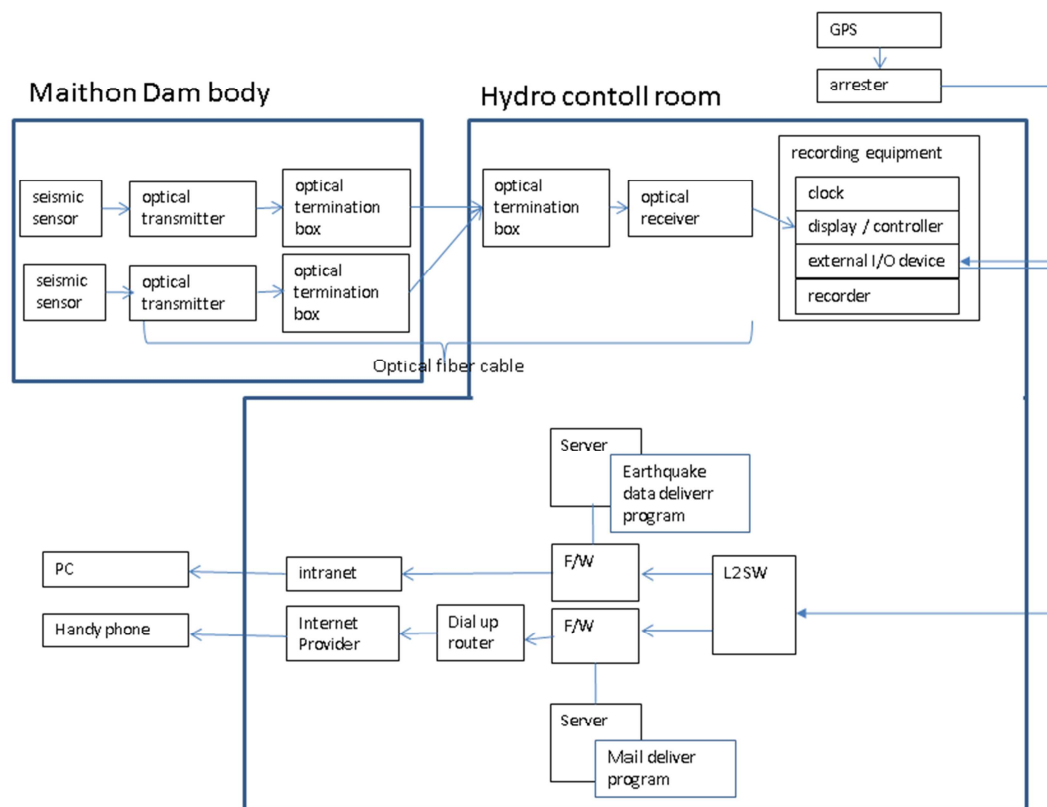
8. Earthquake information system

Most of JWA dams equip seismometers and information systems to deliver the observed acceleration and seismic intensity to the field officers. This information is one of the major trigger for taking emergency action. Seismic intensities observed at adjacent stations installed by Japan Meteorological Agency are also available after a few minutes of an earthquake.

In the case of India, seismic intensity observed by Indian Meteorological Department will be provided not so quick and dense as Japanese one because of less frequency. For strengthening the earthquake response in India, it is highly recommended to install earthquake information system similar to Japan.

Draft schematic chart and major specifications of earthquake information system customized for Maithon dam was presented at Maithon Dam (see Figure 8.1). Also using an image of earthquake information system for Maithon Dam is shown in Figure 8.2.

Earthquake information system



Specification of seismic sensor (example)

Measurement component : 3 (horizon 2, vertical 1)

Maximam accelaration : $\pm 2,000$ gal and over

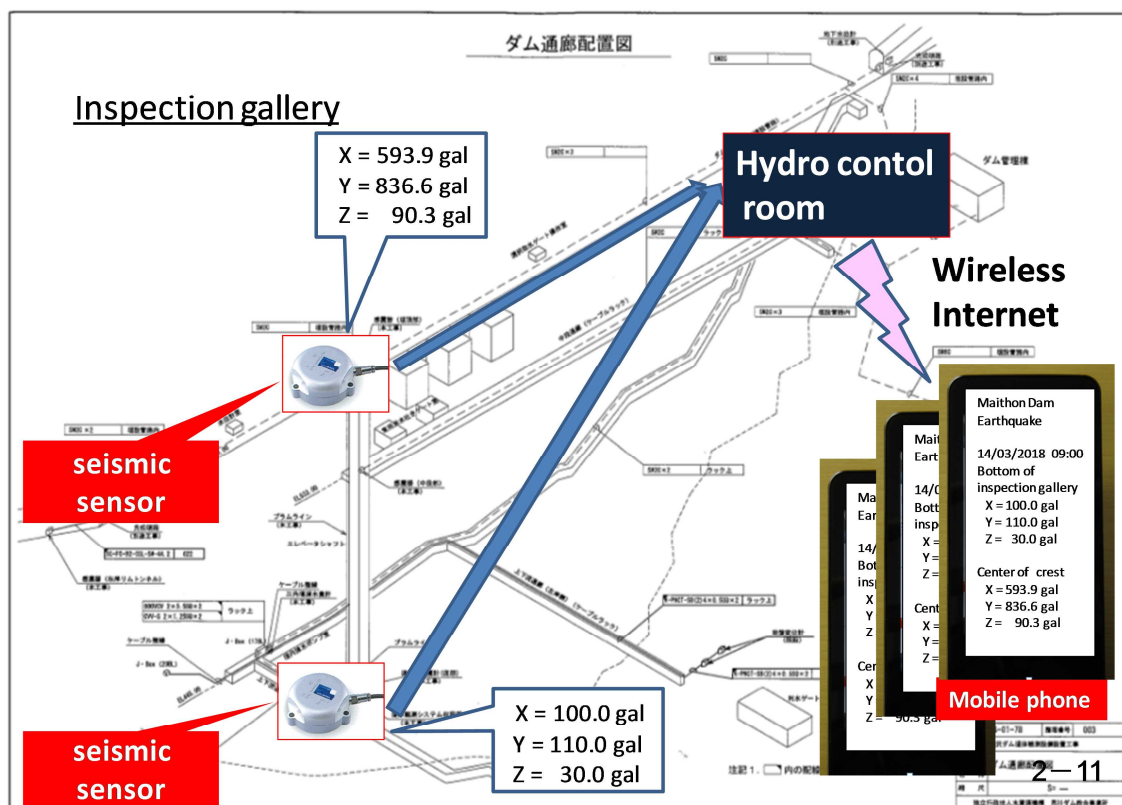
Transmission distance : 500m (seismic sensor – optical transmitter)

Water proof : IPX6 and over

Electric power : from optical transmitter

Arrester : Internal

Figure 8.1 Recommended earthquake information system for Maithon Dam



Display of mobile phone

Report to Dam Manager in real time

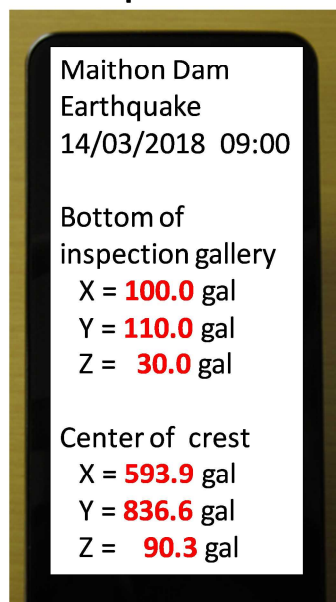


Figure 8.2 Use image of earthquake information system for Maithon Dam

9. Recommendations

The followings are recommendations from JWA team based on the experience in Japan. Most of these have already been shared with UJVNL engineers and CWC officials in the workshop and meeting.

9.1 Reiterating drills and upgrading earthquake response system

Once a great earthquake happens, there will be hundreds of thousands of victims which may include officials managing dams and their families. However, the job responsibility of dam managers will remain even in such a case. Breaching a dam or electric power supply failure will cause secondary damage to general public. Comparing with other disasters, an earthquake is very destructive and not predictable, but it will surely happen in potential earthquake places sooner or later.

It is broadly said that preparedness can mitigate disaster damage. It is true, but hard to implement since the damage by an earthquake may spread extremely wide beyond your imagination. In addition, most of the potential areas have less opportunity to meet actual earthquake because of its infrequency. It implies that people have only limited experience on earthquake and cannot prepare appropriately.

In order to fill the gap of this inexperience, regular drill is one of the effective and practical ways. A drill provides people an opportunity to get some experience on disaster. Every drill gives a chance to identify what is missing where the gap is, what can be improved for better disaster management. Regular and repetitious drill using continuously upgraded scenario will be a practical approach to enhance disaster resilience of all the people concerned.

9.2 Securing fuel in the emergency power generator for 72 hours operation

In general, it is said that initial 72 hours after a disaster or severe accident is very important. In the initial 72 hours, saving human life will be placed the first priority and public-help will not reach to remote areas. Major recovery works will not be initiated during that time. Power failure would last for long time due to collapsed transmission tower or closed road. Petrol and diesel oil would not be delivered to any gas station. After three days, it would be expected that scale of damage by the earthquake may be clarified and some roads and supplies may be recovered. The Japanese government recommends

general public to store water and foods for three days for self-help.

For dam managers, it needs to be assumed that no supply and external support will be provided to dams which will be isolated. In the case of Japan, a dam usually stocks three days foods for staff members and fuels for an emergency generator in order for the dam to be functional for at least 72 hours without any supply and external support.

Power backup



Figure 9.1 Recommendation about power backup

9.3 Acquiring leakage data

If it is needed to diagnose the safety of a concrete dam, there are three basic indicators to be considered, namely leakage, uplift and deformation. Among these, leakage which includes drainage from base rock and leakage from concrete joints and other cracks could be the most tangible and sensitive indicator. The point is continuous, consistent and reliable data which can be a base for subsequent analysis and technical judgement. In principle, there should have been series of data since initial ponding.

In this context, it is firstly recommended as a permanent measure to place triangular weirs at the both sides of drain ditch in the drainage gallery and to store the data of them. The automatic data transfer system may help secure daily consistent data acquisition.

In the case of Ichari Dam in Uttarakhand state, although there is no such available system, the operation record of drainage pump at the bottom of gallery can be utilized. Fortunately, they have already stored for more than several years data, which will help to see the trend of total leakage in the gallery.

Figure 9.2 shows the total leakage and drainage calculated from operation record of the drainage pump and scale of the drain pit. The estimated total leakage is around 40 liters per minute and seems very stable basically. As far as only looking at this data, it could be said that the Ichari Dam seems to be in safe condition.

It should be noted that this is only “total” leakage. Even if frequency of drainage pump operation would be increased after the earthquake, it would not be identified where the water comes from and what kind of countermeasure should be effective. That is the reason why section wise monitoring using a couple of triangle weirs is recommended.

Additionally, drainage holes in the gallery should be kept in healthy condition and the leakage volume should be measured at least once a month. In general, a drainage hole easily be clogged and needs appropriate maintenance such as cleaning or re-bore a hole. Currently, Maithon Dam keeps the drainage holes in healthy condition by the excellent effort of DVC staff.

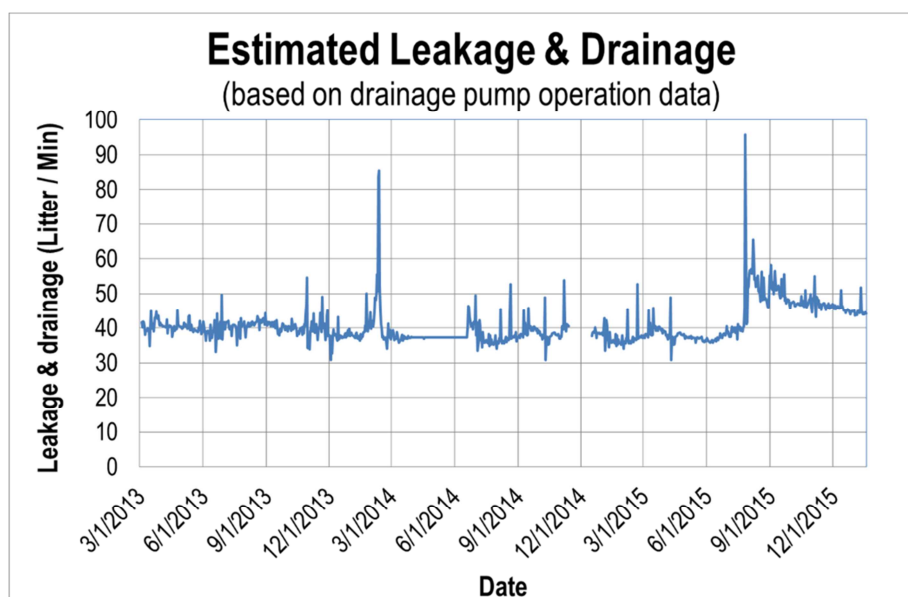


Figure 9.2 Estimated Total leakage and drainage of Ichari Dam

9.4 Other information sharing system

Information sharing among related organizations carries great weights not only the time of earthquake but also the time of natural disaster. This is because decision makers must respond promptly and surely. For that purpose, the exclusive communication plays a major role in the information sharing during disaster. If we use a commercial line during disaster, it will be very difficult to communicate among related organizations in the congestion.

Next, in Maithon dam site, we propose introduction of the in-dam site closed wireless communication system so that information can be shared anytime from anywhere. With this system, communication among the dam site such as administrative office, gallery, power generator room, hydro control room and so on can be done anytime anywhere. Figure 9.3 is shown voice type communication system, and Figure 9.4 is shown voice and moving images type (image type) communication system. Since this system can promptly share information not only in the event of a disaster but also during daily inspections, it will be conducive to efficient and effective work for dam management.

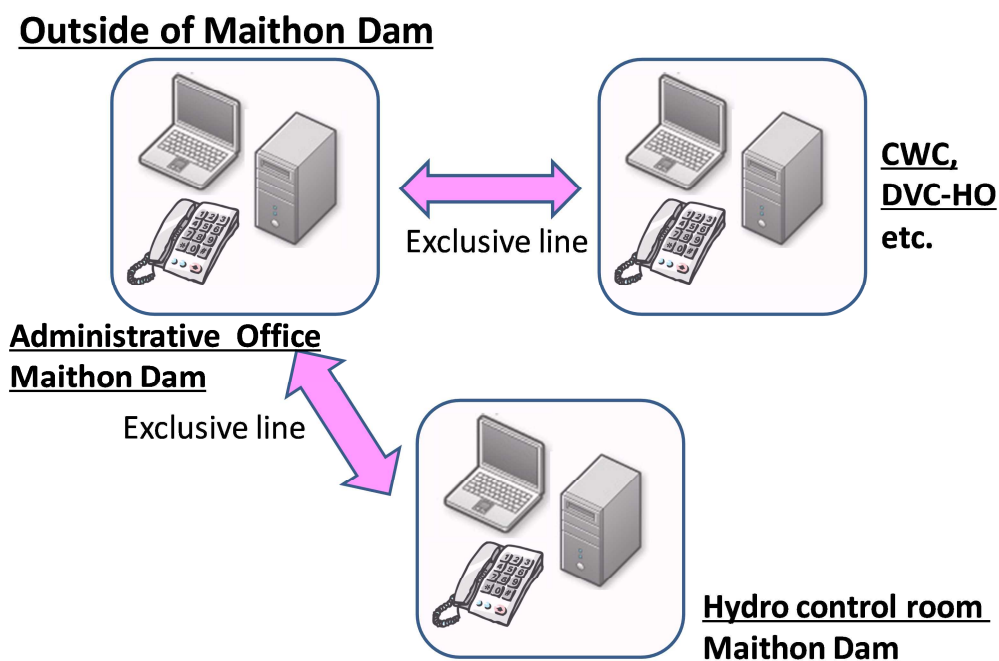
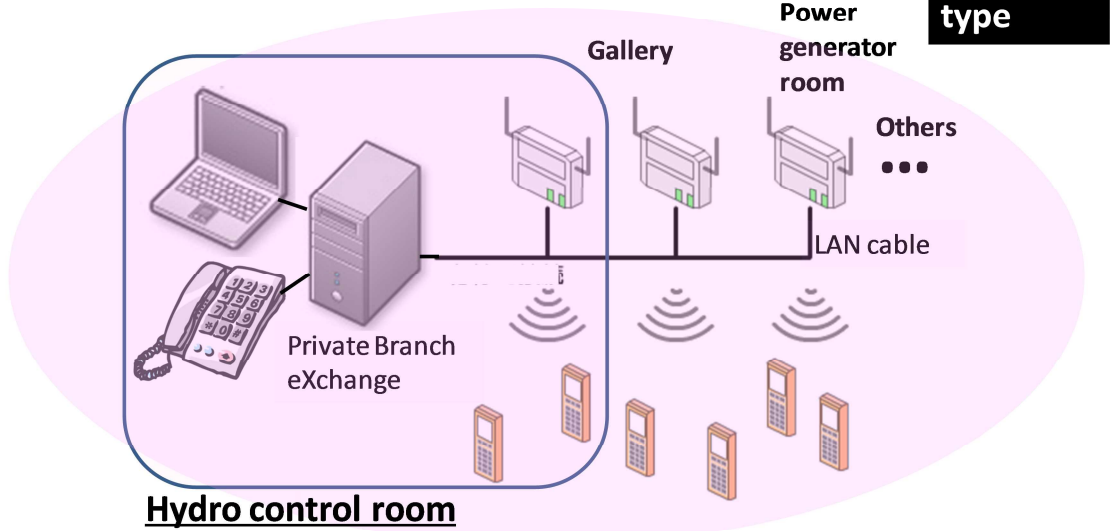


Figure 9.3 Exclusive line among related organizations

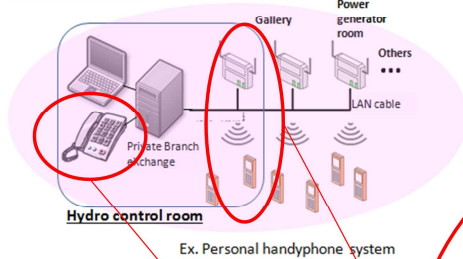
Maithon Dam site



Ex. Personal handyphone system

Securing communication lines

Maithon Dam site



Japan Water Agency



Hydro control room

Use scene in the future

Voice type

Inspector



Drainage gallery pump



Figure 9.4 Closed wireless communication system in-dam site (Voice type)

Maithon Dam site

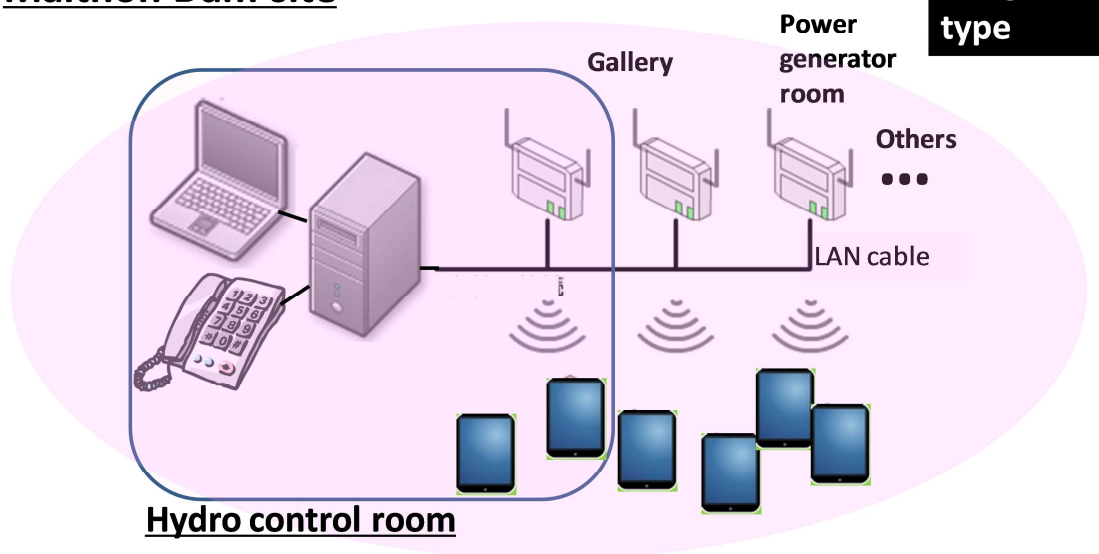
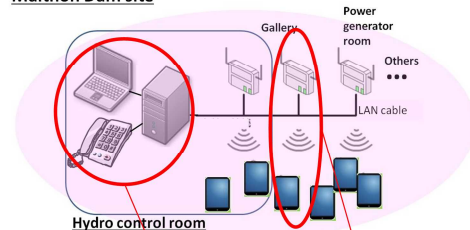


Image
type

Maithon Dam site



Use scene in the
future

Image
type

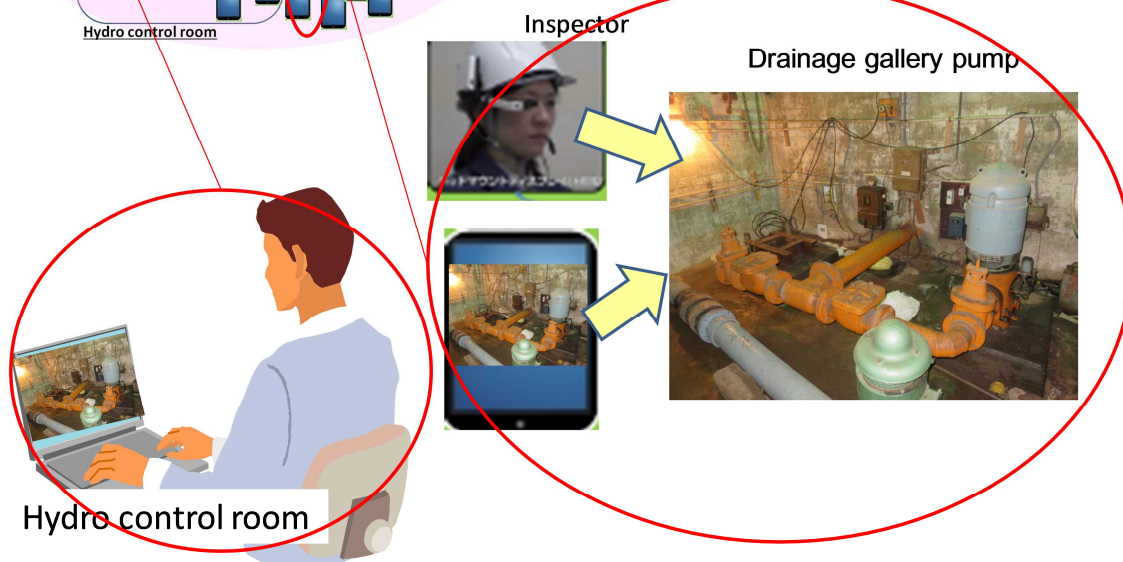


Figure 9.5 Closed wireless communication system in-dam site (Image type)

Appendix

Appendix 1	Presentation materials of 1 st Mission
Appendix 2	Checklist and Manual for Quick Check
Appendix 3	Checklists and Manuals for First inspection
Appendix 4	Drill scenario
Appendix 5	Presentation material on Recommendation

Appendix 1 Presentation materials of 1st Mission





Dam Safety and Disaster Management in Japan

6th July, 2017

Japan Water Agency

trust funded and administrated by 

1

Contents

1. Outline of Japan Water Agency
2. Necessity of Preparedness for Earthquake in India
3. Dam Safety Inspection in Japan
4. How to Evaluate Dam Safety
5. Response to Earthquake


2

1. Outline of Japan Water Agency (JWA)

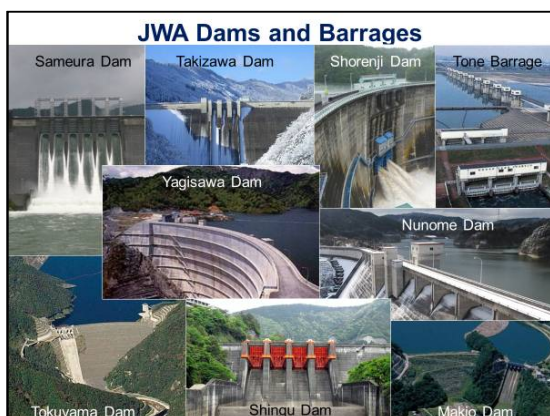
3

JWA's Projects

- ✓ JWA is a **River Basin Organization** and has contributed to water resources management based on the Basic Plan for Water Resources Development for **more than 50 years** in Japan.
- ✓ JWA has been **constructing, operating and reconstructing** water resources management facilities for water use and flood control such as dams, weirs and canals.
- ✓ **43 Dams and about 1,000km primal water route** were established by JWA. These facilities supply city water, agricultural water and industrial water to the 65 million people living in full plan area.



4



Contribution in International Cooperation

- **Network of Asian River Basin Organizations (NARBO)**
 - ✓ NARBO was established in February 2004 by JWA, ADB and ADBI to promote integrated water resources management (IWRM) in monsoon areas of Asia.
 - ✓ NARBO members: 92 organizations from 19 countries
 - ✓ Major Activities: Information sharing, thematic workshops, twinning program, IWRM training and RBO performance benchmarking.
- **Dispatch of Experts**
 - ✓ JWA has dispatched many long-term and short-term experts requested by JICA or other organizations.
 - ✓ JWA has contributed to International Emergency Aid Group or other emergency dispatch at disasters.
- **Consulting Works**
 - ✓ JWA has performed consulting works such as planning, survey and design for enhancement of water management of Asian countries.





6

Objective of This Mission

- Providing operation and maintenance methods during/after the seismic activities, and **draft manuals and check lists of the activities needed to be performed after the seismic activities** from the dam safety view points for field engineers under DRIP.

7

Work Schedule

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Preparation											
1st Mission (checklist)											
Interim Report											
2nd Mission (manual, scenario)											
Interim Report											
3rd Mission (field drill)											
Final Report											

2. The Necessity of preparedness for Earthquake in India

9

Earthquake Zone in India

- Maithon Dam is located seismic zone 3. (MSK-S VII; Very Strong)



CC by sa PlatanMed/Wikimedia
https://en.wikipedia.org/wiki/Earthquake_zones_in_India#/media/File:India_earthquake_zone_map.png

1

Recent Earthquake near Jharkhand

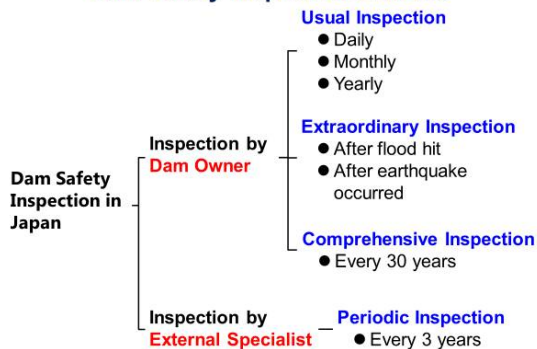


<http://earthquaketrack.com/p/india/jharkhand/recent>

11

3. Dam Safety Inspection in Japan

Dam Safety Inspection Scheme



13

Inspection Items for Each Dam Type

Article 13 of Cabinet Order concerning Structural Standards for River Management Facilities, etc.

Dam type	Height	Inspection item
Concrete Gravity Dam	Less than 50 m	Leakage, Uplift
	50 m or more	Leakage, Uplift, Deformation
Concrete Arch Dam	Less than 30 m	Leakage, Deformation
	30 m or more	Leakage, Deformation, Uplift
Embankment Dam	Uniform type	Seepage, Deformation, Saturated line
	Others	Seepage, Deformation

Standard for Inspection Items and Frequencies						
Management Category		Dam type	Inspection Items and Frequencies			
			Leakage Seepage	Uplift	Deformation	Saturated line
Phase 1	Test submerging	Concrete dam	Once a day	Once a week	Once a day	Once a week
		Embankment dam			Once a week	
Phase 2	At least 3 years after Phase 1	Concrete dam	Once a week	Once a month	Once a week	Once a month
		Embankment dam			Once a month	
Phase 3	After Phase 2	Concrete dam	Once a month	Once in three months	Once a month	Once in three months
		Embankment dam			Once in three months	

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4. How to Evaluate Dam Safety

16

Safety Evaluation of Dam

Evaluation items

by **monitoring data**;

- Deformation of dam body
- Leakage/Seepage from dam body and foundation
- Uplift pressure under dam body (*Concrete dam)
- Saturated line (*Uniform type embankment dam)

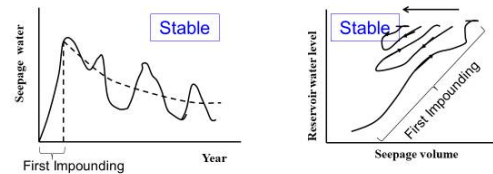
by **visual observation**;

- Deformation of surface of dam body (*Embankment dam)
- Deformation of abutment slope
- Deterioration of concrete; cracking, ageing, etc.
- Leakage/Seepage from dam body and foundation; turbid or not?

17

Evaluation of measurements of dam behavior

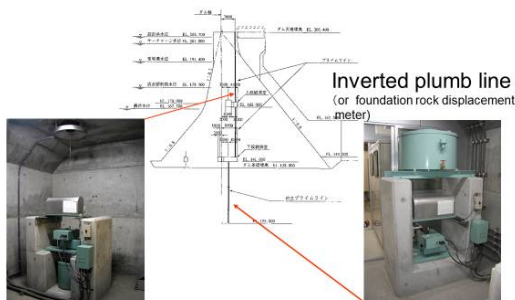
1. Type of the changes of dam behavior as time proceeds
2. Correlation between the external impact factor



3. Peculiar behavior in overall data
4. Difference compared to other dams' behaviors

18

Deformation of Concrete Dam



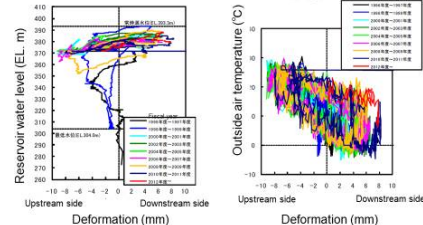
Normal plumb line (or dam deflection meter)

19

Deformation of Concrete Dam

- An example of correlation diagram -

Relationship between X (Deformation in the direction of upstream and downstream) and reservoir water level/ ambient temperature



Decrease in reservoir water level/ Rise in temperature

→ Displacement of dam body in the direction of upstream side

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Leakage from concrete dam body / foundation

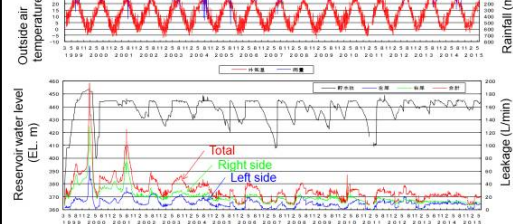


21

Leakage from concrete dam body / foundation

- An example of secular change -

Total leakage water (= foundation drain holes + joint drain holes)



○ Year to year tendency: gradually decreasing in general (Clogging on the leakage path)

○ Reservoir water level rise → Leakage volume increase

○ Ambient temperature (dam body temp.) drop → Leakage volume increase

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Uplift Pressure



Bourdon pressure gauge



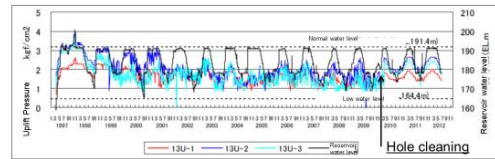
Pore pressure meter*

*Embedded meter tend to lose measuring capability after 20 years .

23

Uplift Pressure

- An example of secular change -



- Uplift pressure tends to drop with the passage of time
- Uplift pressure tends to up after 2010.
- It was caused by cleaning of foundation drain holes.

24

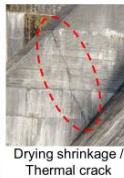
Deterioration of Concrete



Leakage through dam body



Alkali-Silica Reaction



Drying shrinkage / Thermal crack



Crack by large-scale earthquake



Frost attack



Abrasion

25

Deformation of Embankment Dam

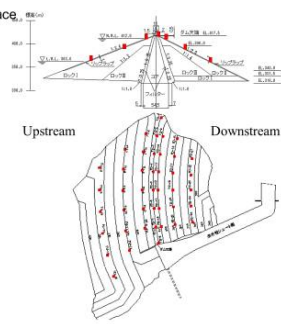
External Deformation and its Measurement Method

- Targets are installed on the surface of dam body.

- Dam crest, upstream and downstream surfaces.

- Targets are surveyed.

- The up-and-down stream direction for horizontal deformation
- The dam axis direction for horizontal deformation
- The vertical direction for settlement



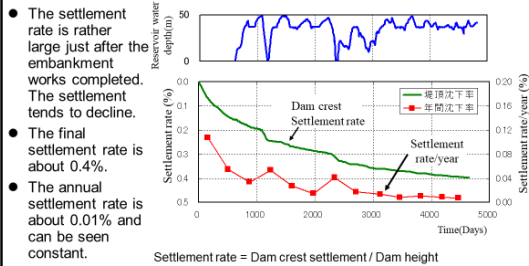
Targets of downstream surface

26

Deformation of Embankment Dam

- An example of secular change -

External Deformation (Vertical)



Settlement rate = Dam crest settlement / Dam height

27

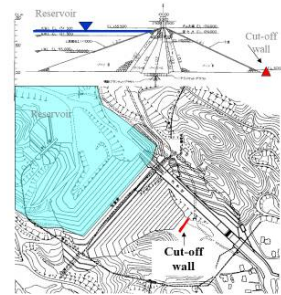
Seepage from embankment dam body/foundation

Seepage

- The seepage amount is measured at the downstream edge of the dam body.
- Seepage water is dammed up by cut-off wall.
- A flow rate is automatically measured by a triangular weir.
- This measuring method is affected by the rainfall in the rock zone.



Triangular weir



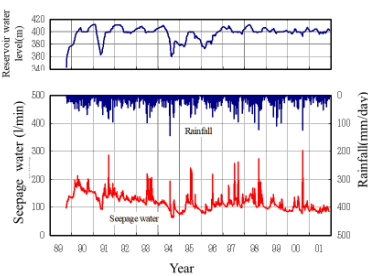
28

Seepage from embankment dam body/foundation

- An example of secular change -

Seepage

- The seepage volume is decreasing and becomes constant with the passage of time.
- The seepage volume changes as the reservoir water level changes.
- The seepage volume increases temporarily during the rainfall, and it decreases after the rainfall.

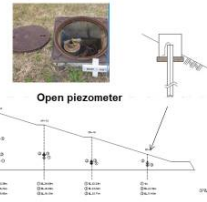


29

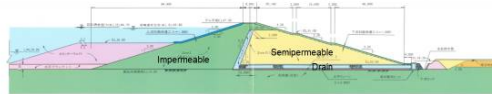
Saturated Line of Embankment Dam

Measurement of Saturated Line by Piezometer

- The saturated line can be drawn by piezometer measurement in the dam body downstream.
- The line is the highest near the dam center and falls downstream.
- The function of drain is to be checked based on the line.



Open piezometer



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5. Response to Earthquake

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Tsunami Disaster
Photo taken at Miyako City, Iwate Prefecture
Courtesy of Tsunami Evacuation Cooperative Association

The Great East Japan Earthquake

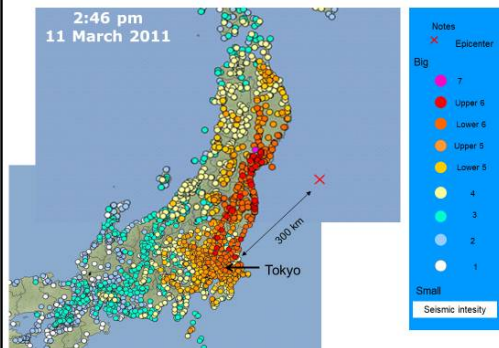
2:46 pm
11 March 2011
Mw 9.0

Catastrophic Damage to Buildings
Otsuchi Town, Iwate Prefecture on 11 March 2011

Source : Ministry of Land , Infrastructure, Transport and Tourism (MLIT)

32

The distribution map of seismic intensity



33

Japanese seismic intensity

JSI	MSK-S	JSI: Japanese seismic intensity MSK-S: Medvedev-Sponheuer-Kárník scale
0	I. Not perceptible	
1	II. Hardly perceptible	
2	III. Weak	
3	IV. Largely observed	
4	V. Fairly strong	
Lower 5	VI. Strong	
Upper 5	VII. Very strong	
Lower 6	VIII. Damaging	
Upper 6	IX. Destructive	
7	X. Devastating	
	XI. Catastrophic	
	XII. Very catastrophic	

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Technological Assistance for Quick Response



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JWA's Emergency Headquarter

11th March 2011
2:46pm Earthquake
2:48pm Investigation Started
2:50pm Set up the EOC
12th March 2011
7:30pm Decision on rehabilitation

Board for latest information

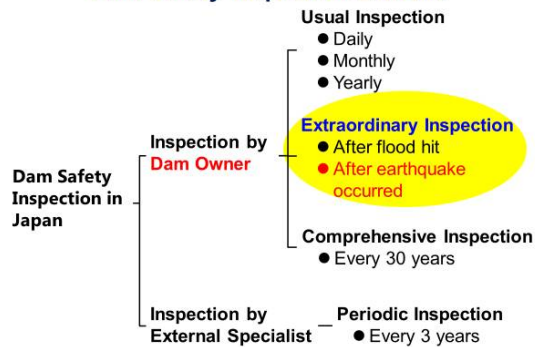
Real-time monitoring

Prompt Information of the status of Dam is required

Emergency Operation Center at JWA HQ on 11 March 2011

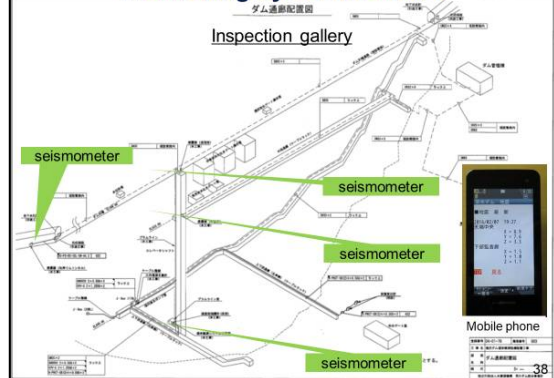
36

Dam Safety Inspection Scheme



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Monitoring by Sesimometer



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Extraordinary inspection immediately after earthquake

- Extraordinary inspection upon an earthquake
 - ~No.1 alert formation: **Intensity 4, or 25 cm/s²** or more at the dam foundation
 - ~No.2 alert formation: Intensity 5, or 80 cm/s² or more at the dam foundation
- Quick Inspection Report :to be made within 1hr
- 1st Inspection Report : to be made within 3 hrs
- 2nd Inspection Report: to be made within 24 hrs including leakage / Seepage, deformation etc.
- If during night time, 2nd IR can be made next morning



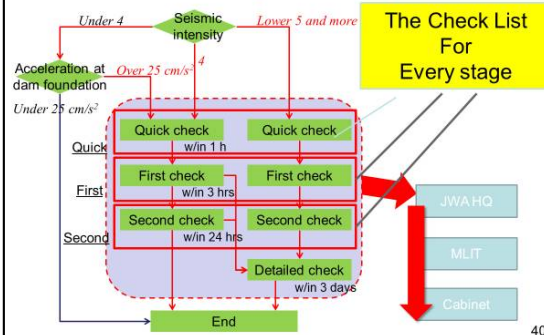
The seismometer in gallery



Display of seismometer

39

Extraordinary inspection aftermath of great earthquake



40

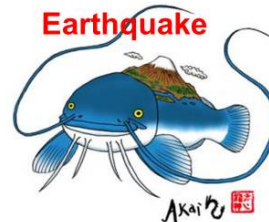
The Check List and Inspection Manual

- For the **Quick Response**, the Check List is prepared for every state.
- Check lists are formulated for each specialized sector, Civil Engineering, Mechanical Engineering, Electrical Engineering

- Manual enables reliable check even in an **emergency** (e.g. earthquake), or by **inexperienced person**.



A disaster strikes when people do not expect it.
If you are prepared, you don't have to worry.



42

Dams in Japan and around the world

Number of large dams in the world

Country	Number of dam
1 China	22,000
2 USA	6,575
3 India	4,291
4 Japan	2,675
5 Spain	1,196
6 Canada	793
7 Korea	765
8 Turkey	625
9 Brazil	594
10 France	569
Others	7,572
Total	47,655

Source: WCD Report (2000)

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Major JWA Dams

Name	Type	Height (m)	Crest Length (m)	Reservoir Capacity (X1,000m ³)	Completion Year
Tokuyama	R	161.0	427	660,000	2008
Naramata	R	158.0	520	90,000	1990
Urayama	PG	156.0	372	58,000	1998
Kusaki	PG	140.0	405	60,500	1976
Misogawa	R	140.0	447	61,000	1996
Takizawa	PG	132.0	424	63,000	2010
Yagisawa	A	131.0	352	204,300	1967
Shimokubo	PG	129.0	605	130,000	1968
Iwaya	R	127.5	366	173,500	1976
Tomisato	PG	106.0	250	52,000	2000
Sameura	PG	106.0	400	316,000	1977

R: Rock fill PG: Concrete gravity A: Concrete arch

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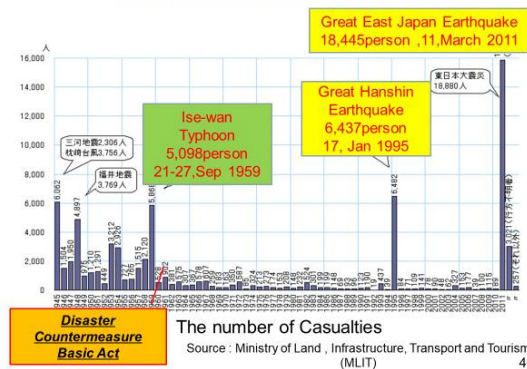
JWA's Technologies

- ✓ JWA has been serving to lead in water resources development and management in Japan with advanced technologies of the water resources management facilities.
- ✓ Those skills have been fully reflected in appropriate operation and maintenance of those facilities, preventing measures for deteriorating facilities, and environmental preservation measures.

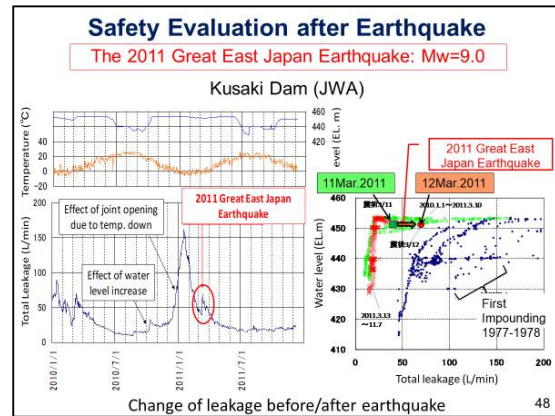
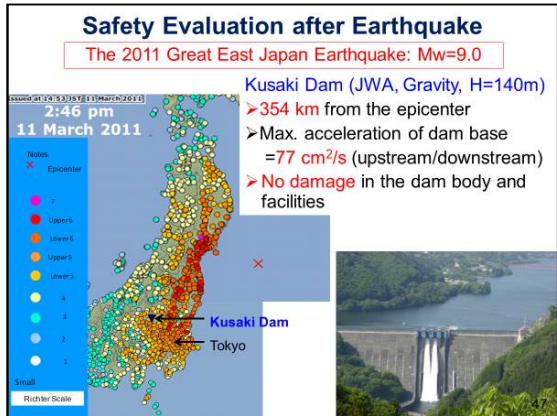


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Historical Disaster in Japan



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Outline of the Checklist and the Inspection Manual after the Seismic Events

July, 2017

Kazumi SASAKI
International Affairs Division,
Water Resources Engineering department,
Japan Water Agency

trust funded and administrated by  THE WORLD BANK

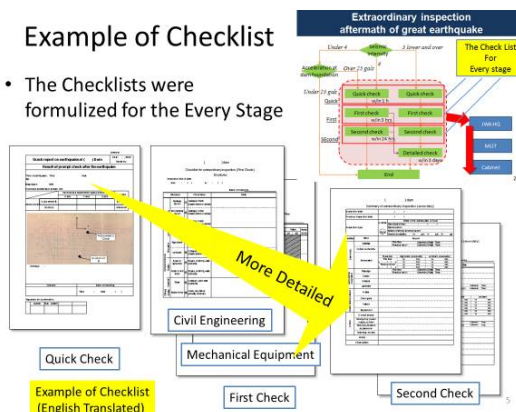
Contents

1. Outline of the Checklist of JWA
2. Outline of the Inspection Manual of JWA
3. The Inspection Manual of Ichari Dam
(on Dam Structure; on Mechanical Facilities; on Electric and Telecommunication Facilities)

1. Outline of the Checklist of JWA

Example of Checklist

- The Checklists were formulated for the Every Stage



The contents of the Checklist

- The Checklists for each step, Quick Check, First Check, Second Check should be submitted within 1h, 3h and 24h respectively.
- The items of the Checklists of each step were chosen by considering both the restrained time and the importance of the items.
- We have to send the checklists to Ministry of Land, Infrastructure and Transport which manages our organization within the said timeframe.

2. Outline of the Inspection Manual of JWA

The Inspection Manuals of JWA

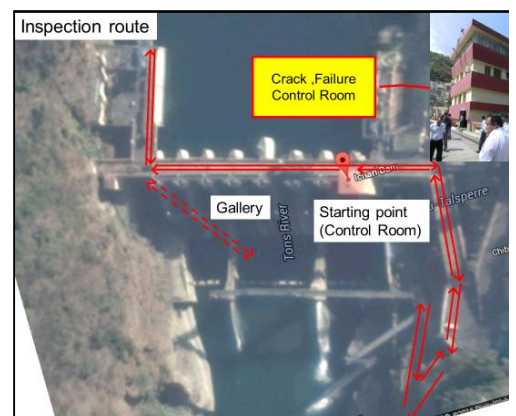
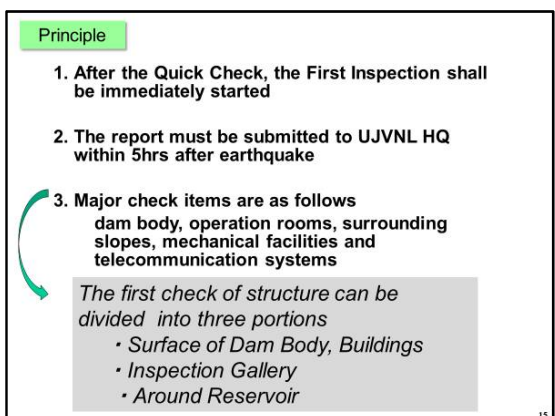
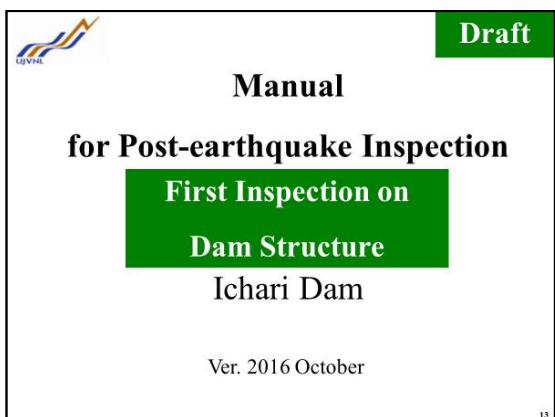
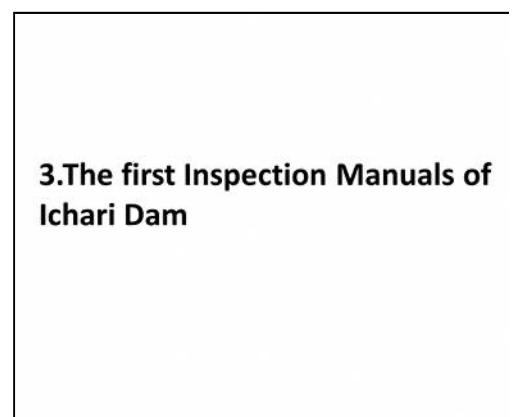
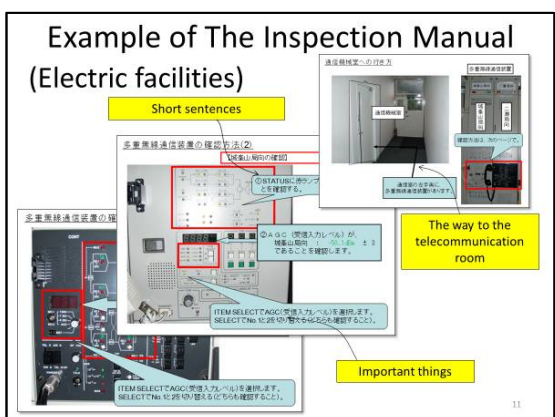
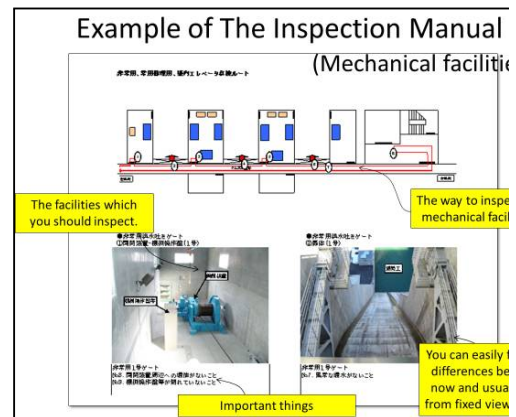
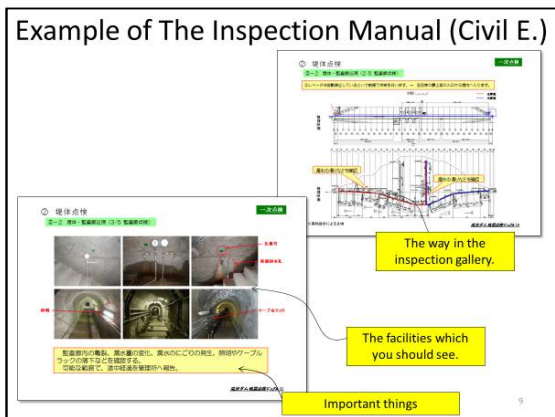
- There were no manual which anyone could understand. But at some remote snowy dam management office, we made the manuals because sometime everyone could not get to the office soon.
- Up to now, the manuals were widely spread to other dam management offices.

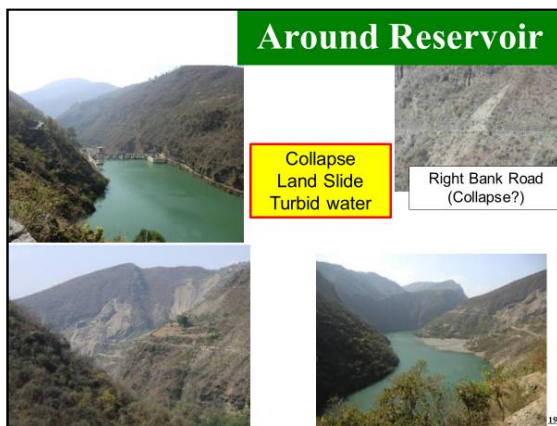
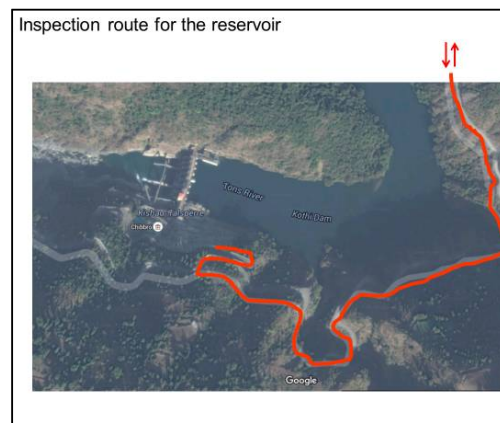
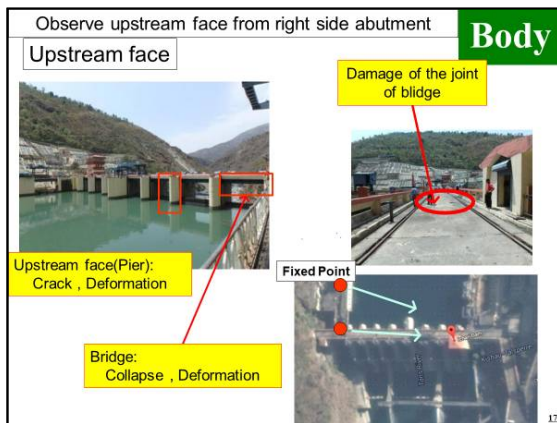


The principle of the inspection manuals

- Find the way easily
Where you should walk!
- Find the facilities easily
What you should see!
What are important things
To be written by short sentences
To be visible
To be handy
- Find easily the differences between now and normal times
To fix the viewpoints







Fill out reporting form and submit

Ichari dam

Checklist for extraordinary inspection (First Check)

Structures

Structure	Check item	Result	Remarks
Dam	Upstream face		
	Downstream face		
	Abutment		
	Spillway		
Gate	Gate structure		
	Gate operation		
	Gate maintenance		
	Gate safety		
Intake	Intake structure		
	Intake operation		
	Intake maintenance		
	Intake safety		
Tunnel	Tunnel structure		
	Tunnel operation		
	Tunnel maintenance		
	Tunnel safety		
Other	Other structure		
	Other operation		
	Other maintenance		
	Other safety		

Fill in observed

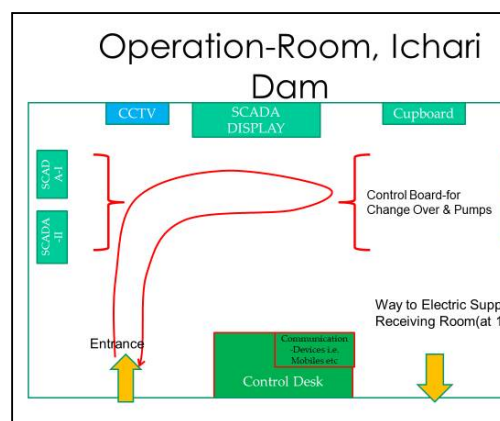
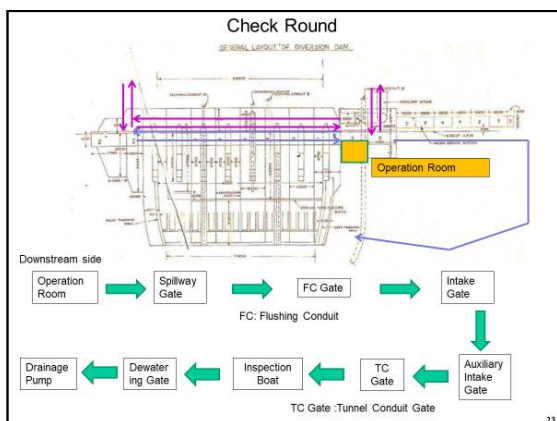
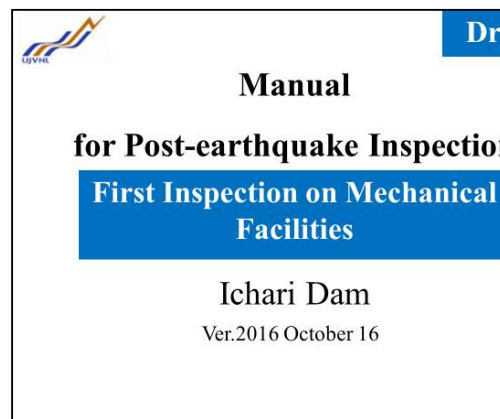
Report to HQ of UJVNL Ltd.

Report with Result of Mech. and E&T by E-mail to

Contact Person of UJVNL Head Quarter


Name	
Post No.	
E-mail	

21



Method of confirmation about Communication Equipment


Cable phone



Put a call in to another telephone in office

voice call check (Cable line)
(* * * - * * * *) to intended party
(* * * - * * * *) voice call check

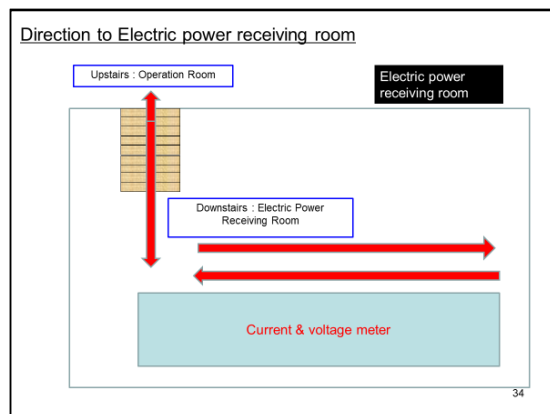
Mobile phone



Put a call in to another telephone in office

voice call check
(* * * - * * * *) to intended party
(* * * - * * * *) voice call check

33

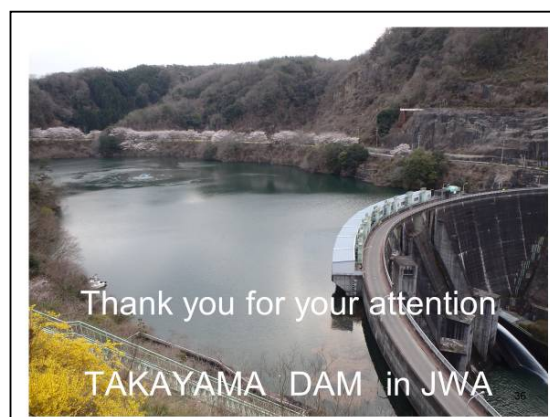


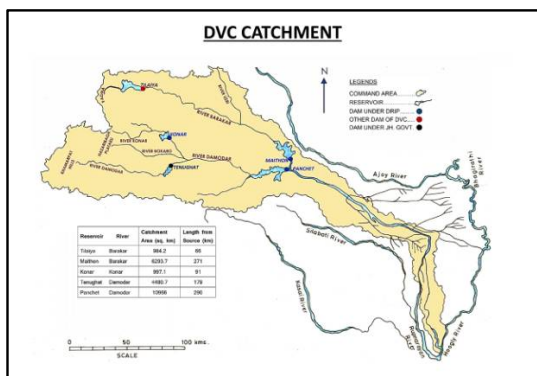
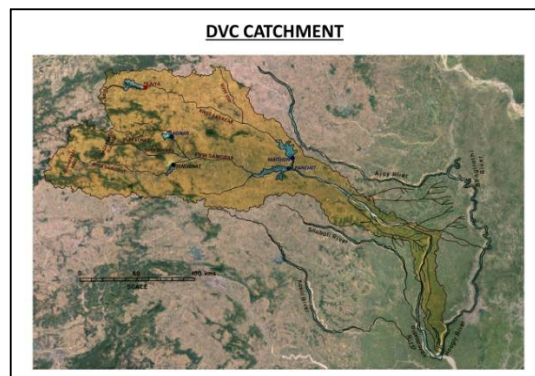
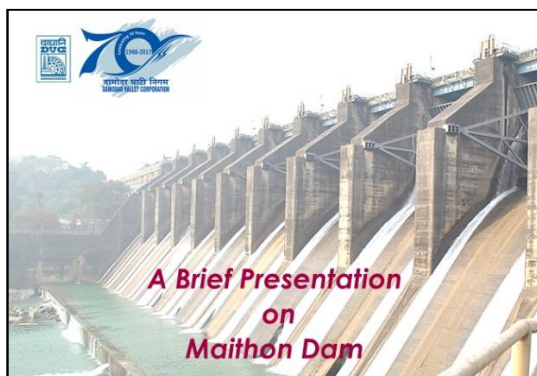
Check List

- Fill in column
- Report Executive Engineer urgently!

khai Dam Checklist for Initial/regular/urgent inspection Electric and Telecommunication equipment					
Inspector's Name & Date					
Room	Item	Check items	Procedure	Pass / Fail	Remarks
Communication equipment	Wireless communication equipment (e.g. mobile phone, IS-95C)	(1) Call	Make Check		
		(2) Receiving data check (Received signal level dBm)	Visual Check		
	Mobile communication equipment (e.g. VHF, UHF, etc.)	(1) Call	Make Check		
		(2) Receiving data check (Received signal level dBm)	Visual Check		
Electric power receiving and supply equipment	Power supply (e.g. electric company)	(1) Normal (measuring data check)	Visual Check		
		(2) Emergency generator	Normal (Status test run Check: Fuel, cooling water, starting etc.)	Test Run/Visual Check	
	Fuel Tank	(1) Leaking, Broken, Leak of fuel, etc.	Visual Check		
		(2) Dam control (e.g. dam)	(1) Normal (Check display panel)	Visual Check	
Electric equipment (e.g. transformer, switch, etc.)	(1) Normal (Check display panel)	Visual Check			
	(2) Monitoring device	(1) Normal (Check display panel)	Visual Check		
Others					

35





SALIENT FEATURES

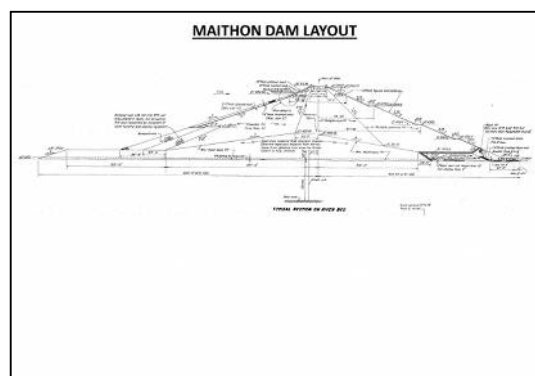
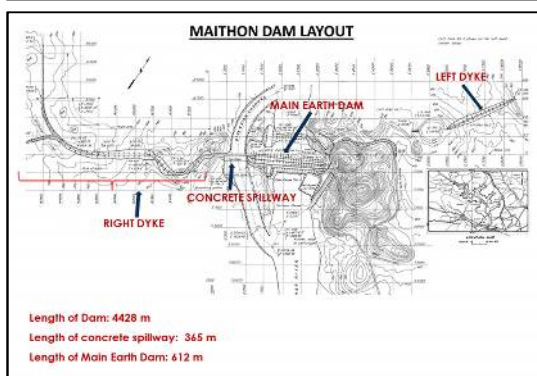
Features		Maithon
General	Inauguration	27.09.1957
	River	Barakar
	District	Dhanbad
	State	Jharkhand
	Location	Latitude: 23°47' Longitude: 86°49'
Hydrological	Catchment Area (km ²)	6293
	Avg. Annual Precipitation (cm)	114
	Avg. Annual Runoff (MCM)	2700

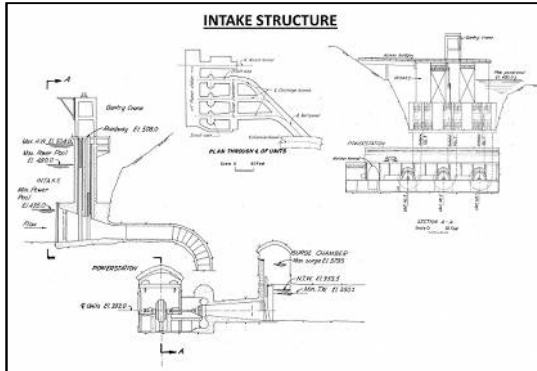
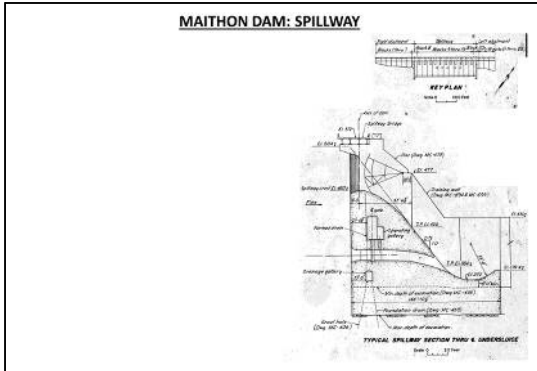
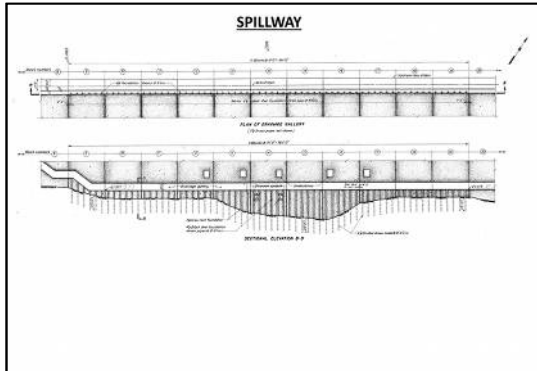
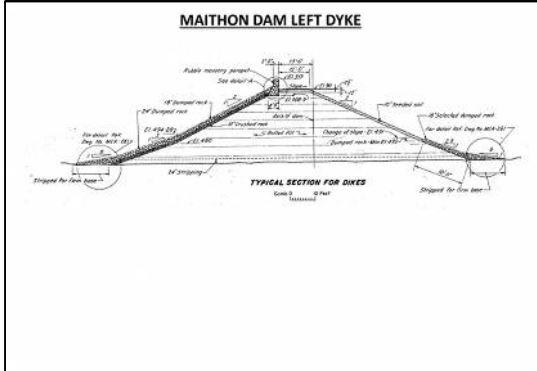
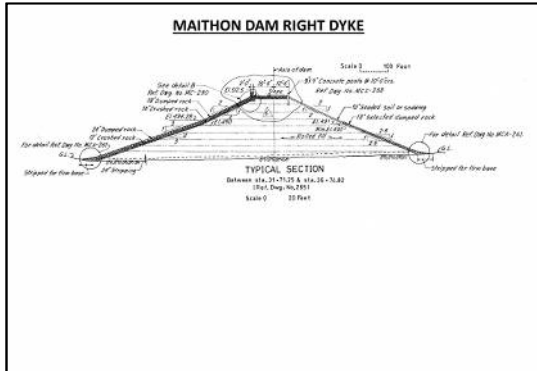
SALIENT FEATURES

Structural		
Type	Composite : Earth & Concrete	
Maximum Height above foundation (m)	56.88	
Overall Length (m)	4426.76	
Type of Spillway	Ogee	
Crest gate type	Tainter	
Crest Gate Number	12	
Crest Gate Size (m x m)	12.19 X 12.5	
Undersluice type	Vertical lift	
Undersluice Number	5	
Undersluice Size(m x m)	1.73 X 3.05	

SALIENT FEATURES

Reservoir		
Dead Storage Level (m)	132.59	
Above MSL	93	
Dead Storage (MCM)	146.51	
Conservation Level (m)	441	
Above MSL	441	
Conservation Storage (MCM)	150.90	
Max. Utilizable Flood Management Level (m)	334	
Above MSL	63.5 MW	
Flood Management Storage(MCM)	38.71	
Installed Capacity	Horizontal Shaft Francis	
Type of Turbine	Maximum Head (m)	





Appendix 2 Checklist and Manual for Quick Check



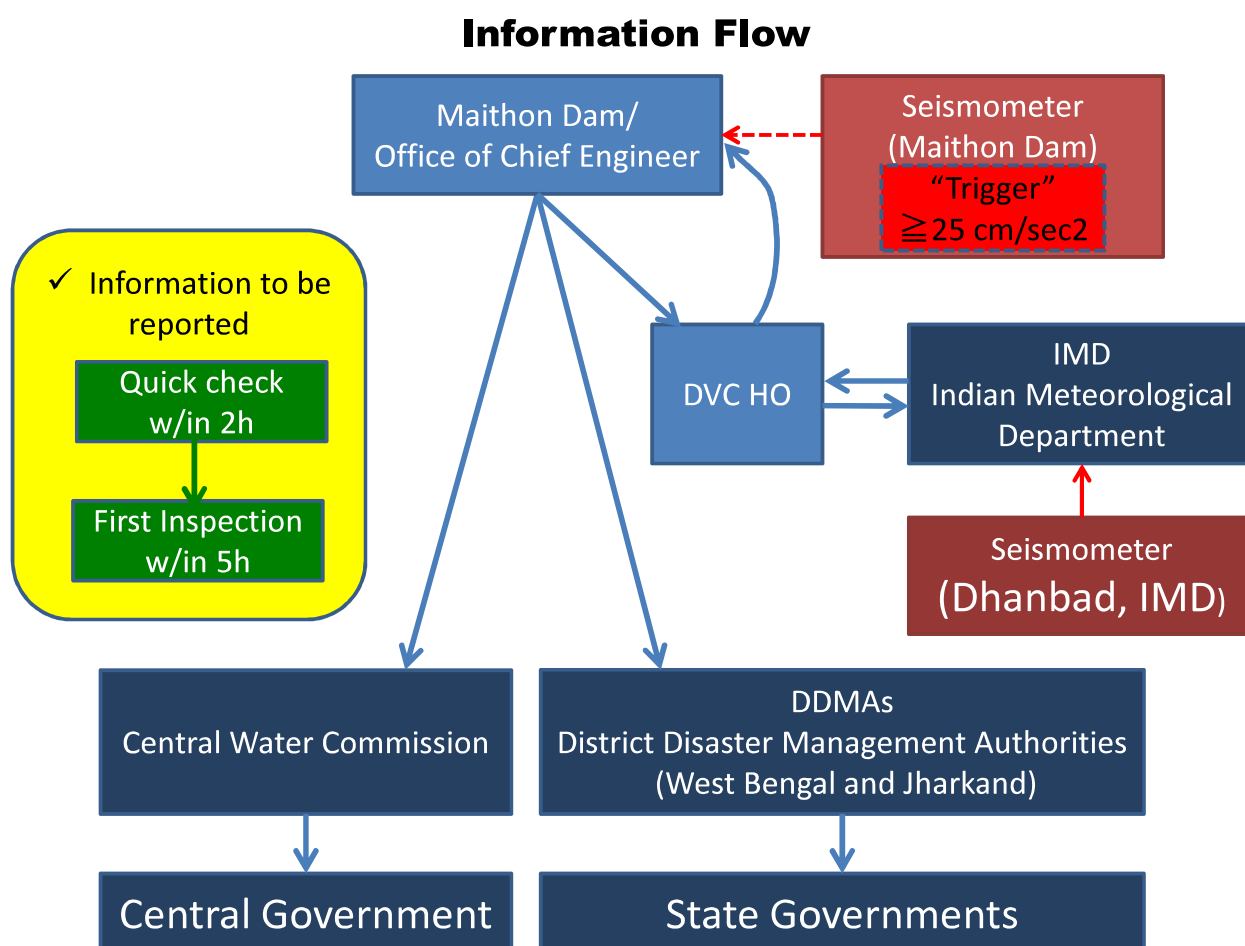
Draft

Manual for Post-earthquake Inspection

Quick check

Maithon Dam

Ver. March.2018



Earthquake Intensity for Action

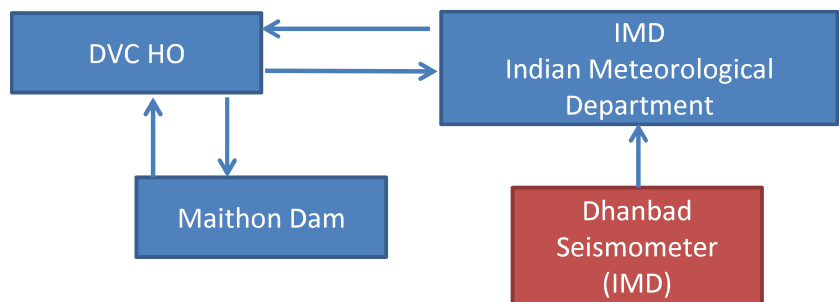
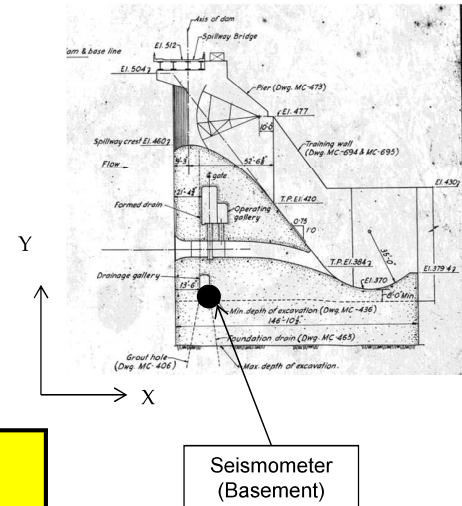
Installed seismometer
(Basement)

Acceleration

$\geq 25 \text{ cm/sec}^2$

OR

Seismic information from HO of DVC
(Data from Indian Meteorological Department)

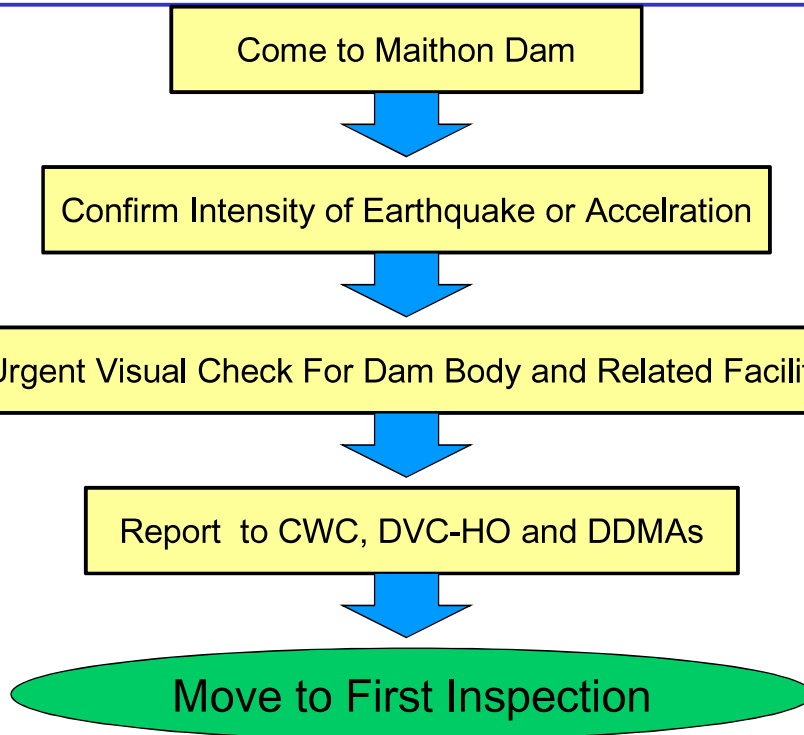


Quick Check

Purpose of Quick Check

To urgently report received seismic intensity and acceleration and any obvious damage which leads to dam failure, within two hours

Procedure

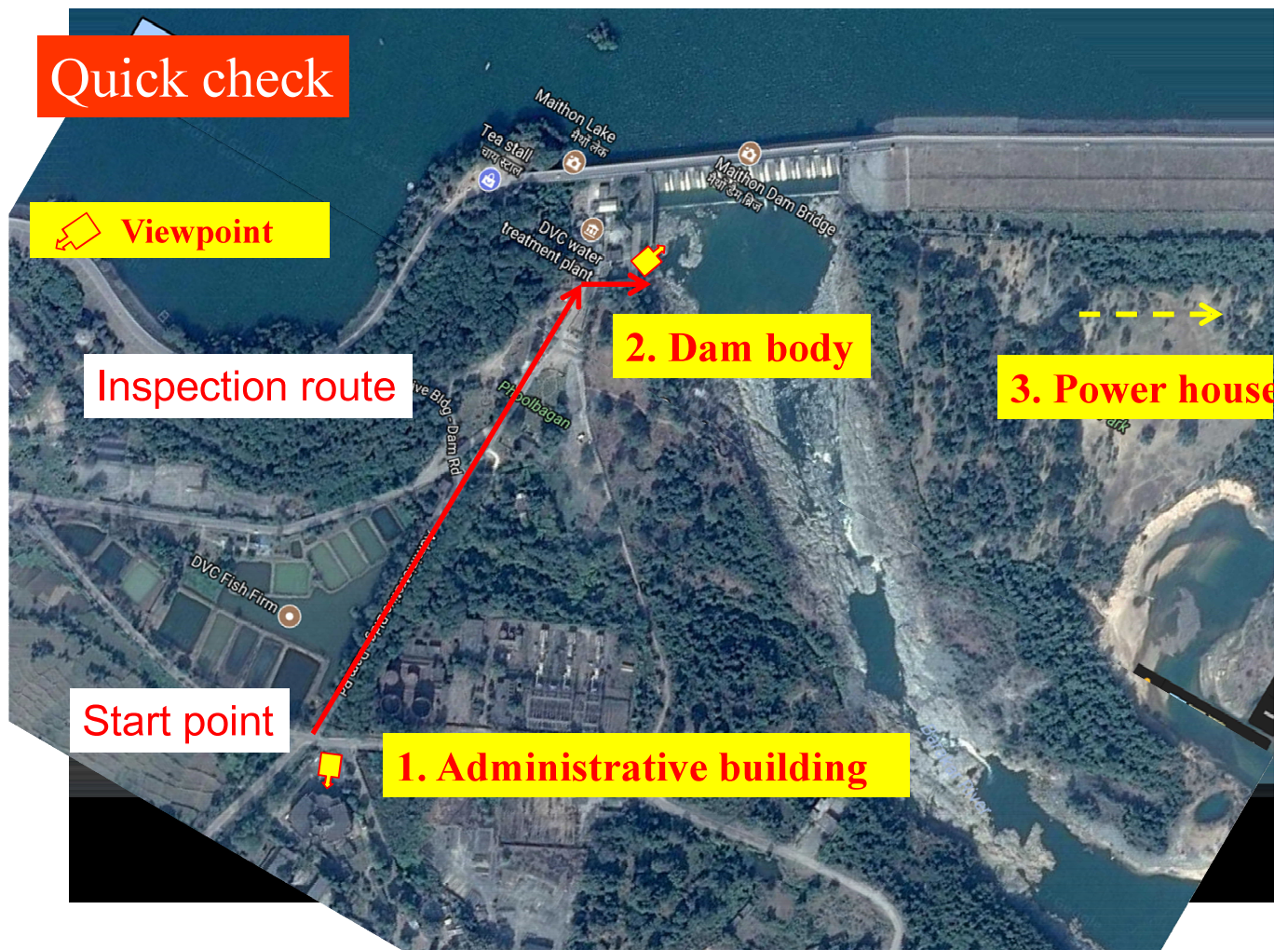
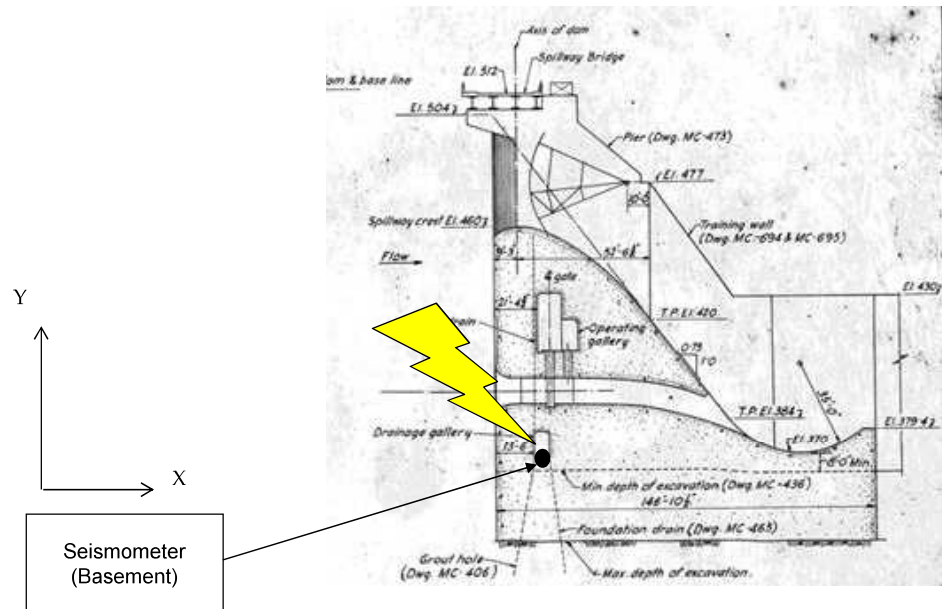


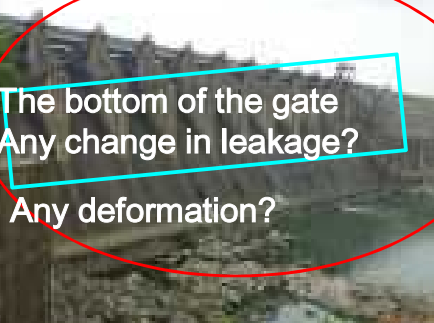
Tools for inspection

- ✓ Writing kit
- ✓ Camera
- ✓ Mobile phone / Walkie-Talkie
- ✓ Helmet
- ✓ Keys
- ✓ Flashlight
- ✓ Checklist
- ✓ Manual



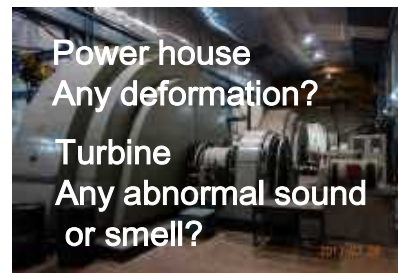
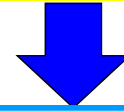
Collecting the data of Earthquake Intensity





The bottom of the gate
Any change in leakage?
Any deformation?

Request hydel staff of inspection through phone



The report of the earthquake intensity

Quick Check

Report on earthquake response of Maithon Dam	Date: / / Serial No.			
Report on extraordinary inspection (Quick Check)				
Following are the result of quick inspection after the earthquake				
Inspection result				
<div style="margin-left: 40px;"> 1 Dam body 2 Power house 3 Gates, turbines 4 Others </div>				
<div style="border: 1px solid black; padding: 10px; margin-top: 20px;"> <p>State of the earthquake or flood _____ : , / /</p> <p>Event date & time: _____</p> <p>Event location: _____</p> <p>Seismic Intensity at nearest point: _____ gal, Y= _____ gal, Z= _____ gal</p> <p>Observed Acceleration X= _____ gal</p> </div>				
$1 \text{ gal} = 1 \text{ cm/sec}^2$				
Signature for confirmation				
Chief	Deputy Chief	Officer in charge	Staff	Dispatch date & time
				: , / /

Report to HO of DVC

Report by E-mail to

Contact Person of DVC Head Office	
	Name Post No. E-mail

Report to CWC

Report by E-mail to

Contact Person of CWC	
	Name Post No. E-mail

Report by E-mail to

Contact Person of DDMA of West Bengal / Jharkand	
	Name Post No. E-mail

[Quick Check Report Finish](#)
[Switch to](#)
[First Inspection](#)

Appendix 3 Checklists and Manuals for First inspection

Maithon Dam

Checklist for extraordinary inspection (First Inspection) Structures

Inspection time & date
from : / /

to : / /

Name of inspector _____

Structures				Check items	State
Dam	Concrete Body	Upstream face	b	Crack (visually observe or camera)	
		Downstream face (Spillway section)	d 4, 10	Leakage, Crack (visually observe or camera)	
		Downstream face (Non-spillway section)	6, 9	Leakage, Crack (visually observe or camera)	
		Operation Gallery	13	Leakage, Crack (visually observe or camera)	
		Drainage Gallery	7, 8	Leakage, Crack (visually observe or camera)	
		Bridge	c	Collapse, Deformation (visually observe or camera)	
		Collimation Line	e	For Straight Alignment	
	Main Earth Dam	Upstream face	f	Settlement, Deformation (visually observe or camera)	
		Downstream face	g	Seepage, Settlement, Deformation (visually observe or camera)	
		Road (Crest of Dam)	h	Crack, Settlement (visually observe or camera)	
		Parapet Wall	i	Crack, Settlement (visually observe or camera)	
	Right Dyke (Toll 1 to Middle School)	Downstream face	B	Seepage, Settlement, Deformation (visually observe or camera)	
		Road	A	Crack, Settlement (visually observe or camera)	
		Parapet Wall	C	Crack, Settlement (visually observe or camera)	
	Left Dyke	Road	E	Crack, Settlement (visually observe or camera)	
	Others	Proposed Control room	a	Crack, any failure (visually observe or camera)	
		Intake Structure	j	Crack, any failure (visually observe)	
		Bridge (Access road to Intake Structure)	k	Collapse, Deformation (visually observe or camera)	
		Maintenance Walkway	5, 11, 12	Collapse, Deformation (visually observe or camera)	
Power House	Access	Entrance	F	Collapse, Deformation (visually observe or camera)	
		Access Tunnel	G	Leakage, Crack, Collapse (visually observe or camera)	
	Generating Bay	Top Floor	H	Leakage, Crack (visually observe or camera)	
		Base Floor	I	Leakage, Crack (visually observe or camera)	
Around Reservoir	Roads	Left bank	D	Collapse, Slope Failure (visually observe or camera)	
		Access Road		For Accessibility	
	River	Downstream protection works : Training Walls	4, 10	Crack (visually observe or camera)	

Maithon Dam
Checklist for first inspection
Mechanical facilities
Location:- Maithon Dam, Distt-Dhanbad, Jharkhand-828207

Implementation	Date	~Date	Time
Name			

Name of Equipment		Check Item	Procedure	State																							
				Spillway Gate												Under Sluice Gate						Pump		Reference			
				#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#1	#2	#3	#4	#5	#1	#2					
Gates	Hoist foundation structure	Crack, Deformation	Visual Check																								
	Gate body and seals	Deformation	Visual Check																								
		Leakage	Visual Check																								
	Hoist (Opening and closing) Equipment	Leaning	Visual Check																								
		Leak of oil	Visual Check																								
	Lifting/Lowering chain	Broken	Visual Check																								
	Trunnion	Deformation	Visual Check																								
Drainage Gallery pump	Leaning	Visual Check																									

Remark

Maithon Dam
Checklist for first inspection
Electric, Telecommunication and information facilities
Location:- Maithon Dam, Distt-Dhanbad, Jharkhand-828207

Inspectoin time & date

from : / / to : / /

E,TC,I Communication Equipment	Check items		Procedure	Check	Crest gate(12 nos.)												Under sluice gate (5 nos.)					Remarks
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	
Communication Equipment	Mobile communication equipment	call	Voice Check																			In C/R
	Cable communication	call	Voice Check																			In C/R
	Power supply	measuring data check (normal/abnormal)	Visual Check																			In Main ACDB near C/R
	Emergency generator	check status (leaning, broken, Crack of floor, leak of oil, liquid on the floor) and Test run	Visual Check & Test run																			In DG Room
Electric power receiving and transforming equipment	Emergency generator system	check status (leaning, broken, Crack of floor, leak of oil, liquid on the floor, fuel)	Visual Check																			In DG Room
	Radiator	check status (leaning, broken, liquid on the floor)	Visual Check																			In DG Room
	Operation board	measuring data check (normal/abnormal)	Visual Check																			In DG Room
	Remote operation Board	check status (display/panel)	Visual Check																			In Future
Electrical Equipment	Observational equipment (water level, rainfall etc.)	check status (display, record)	Visual Check																			In Future
	Monitoring camera	check status (display/panel)	Visual Check																			In Future
	Local operation Board	check status (leaning, measuring data, lighting position, lighting around gate hoist)	Visual Check																			Each gate site
	Local operation Board for dewatering pumps in Dam Gallery	check status (leaning, measuring data, lighting position)	Visual Check																			Near Pump

Remarks:



Draft

Manual

for Post-earthquake Inspection

First Inspection on

Dam Structures

Maithon Dam

Ver. March.2018

Purpose of First Check

To urgently confirm the state of dam safety and mechanical, electric, information and communication facilities

Principle

- 1. After the Quick Check, the First Inspection shall be immediately started**
- 2. The report must be submitted to CWC and DVC HO within 5hrs after earthquake**
- 3. Major check items are as follows**
 - control room, dam, dyke, power house, intake, river, around reservoir.**
 - mechanical, electric, information and communication facilities.**

Tools for inspection

- ✓ Writing kit
- ✓ Camera
- ✓ Mobile phone / Walkie-Talkie
- ✓ Helmet
- ✓ Keys
- ✓ Flashlight
- ✓ Checklist
- ✓ Manual

Checklist for preliminary inspection (Pre-Check)	
Inspection Item	Inspection Result
1. General appearance	
2. Structure	
3. Foundation	
4. Drainage	
5. Access road	
6. Slope of mountain	
7. Power house	
8. Right dyke and left dyke	
9. Maintenance walkway	
10. Surface of dam body	
11. Intake structure	
12. Control rooms	



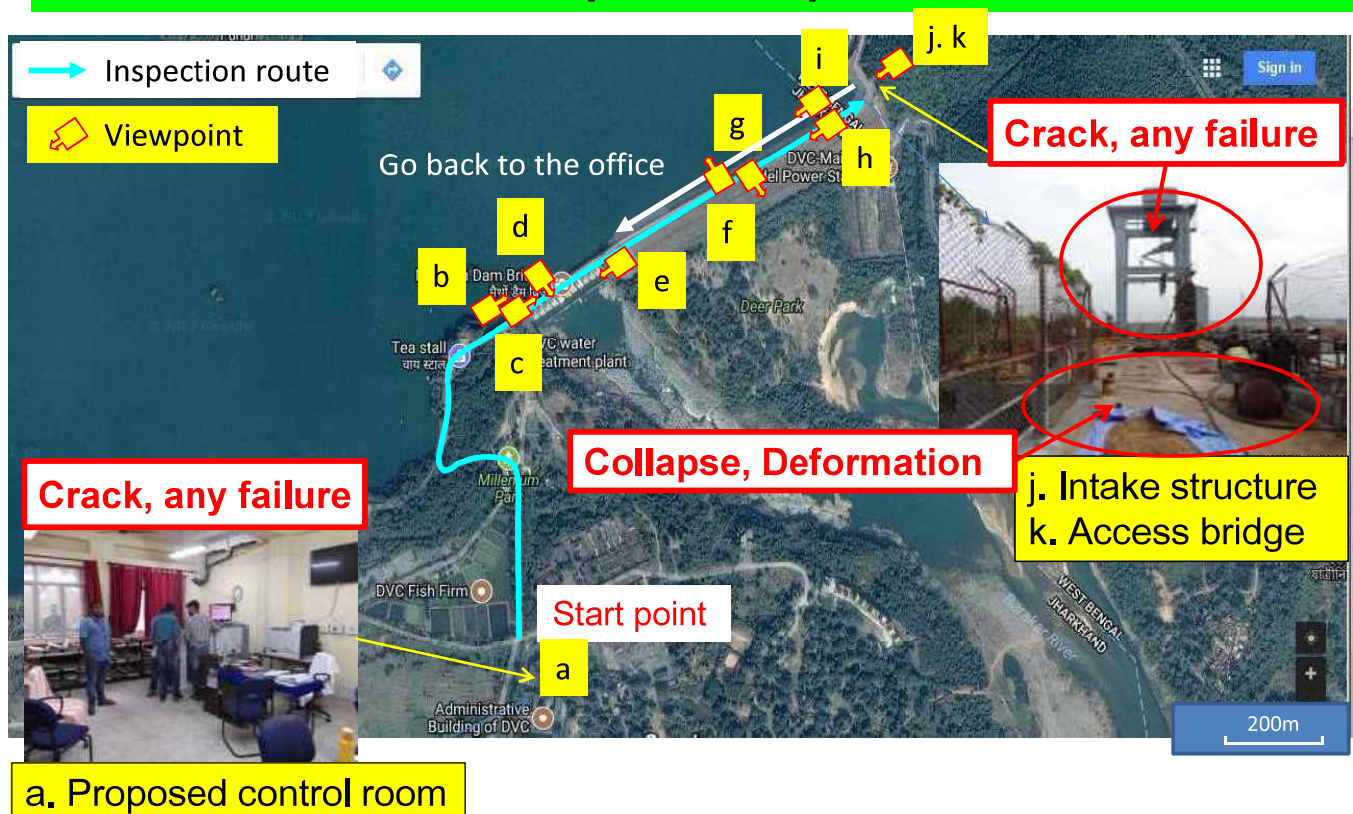
The first check of civil engineering structures can be divided into three routes

- **Inspection route No.1 (Civil A)**
 - ✓ *Control rooms*
 - ✓ *Surface of dam body*
 - ✓ *Intake structure*
- **Inspection route No.2 (Civil B)**
 - ✓ *Surface of dam body*
 - ✓ *Drainage gallery and inspection gallery*
 - ✓ *Maintenance walkway*
- **Inspection route No.3 (Civil C)**
 - ✓ *Right dyke and left dyke*
 - ✓ *Power house*
 - ✓ *Access road*
 - ✓ *Slope of mountain*

First Inspection Route No.1

Civil A

Inspection route No.1 for First check (Civil A)



Observe concrete dam face & bridge from photo points - **Watch your Step!**

Body

b. Upstream face



Crack

c. Bridge of dam crest



Collapse, Deformation

e. Collimation line (Spillway section)



Straight alignment



 Viewpoint



Observe downstream face & bridge from concrete dam crest

Body

d. Downstream face (Spillway section)

 Viewpoint



Crack, Leakage

Observe up-downstream face, road and parapet wall from embankment dam crest

Body

Settlement, Deformation



f. Upstream face

Seepage, Settlement, Deformation



g. Downstream face

Crack, Settlement



h. Road (Crest of dam)

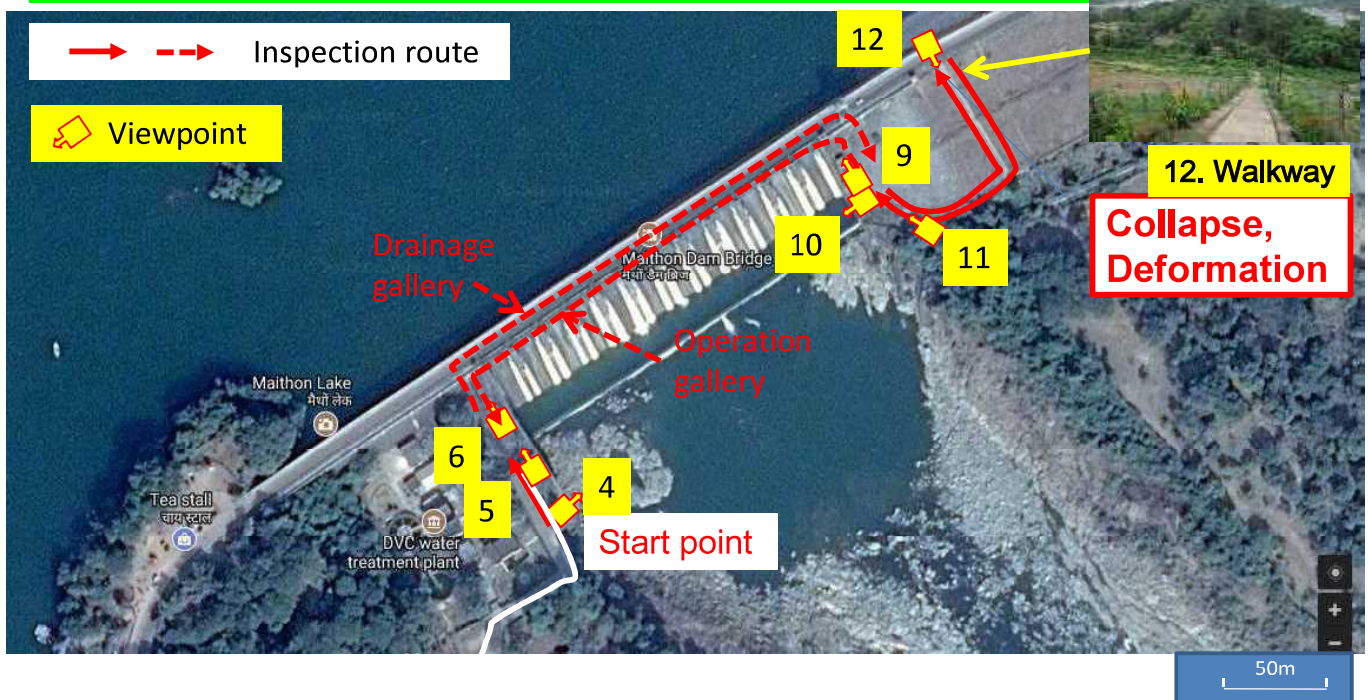


i. Parapet wall

First Inspection Route No.2

Civil B

Inspection route No.2 for First check (Civil B)



Observe downstream face & protection works from walkway

Body

6.& 9. Downstream face (Non-spillway section)

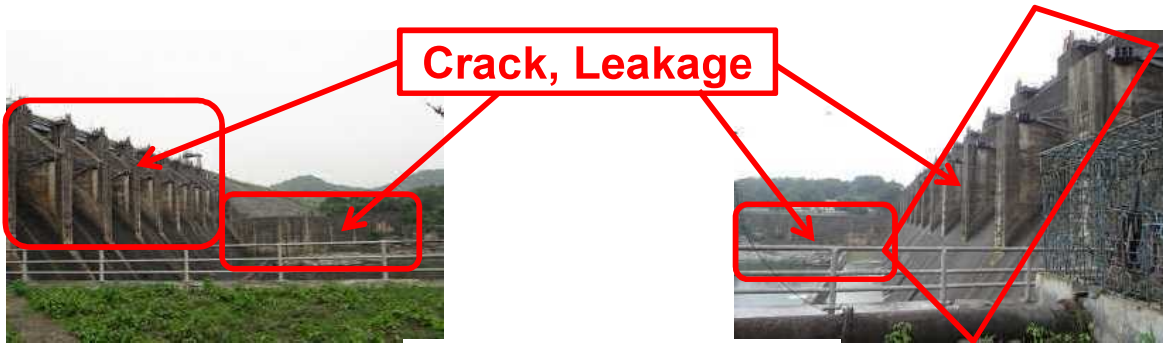


5. Walkway

Observe downstream face & protection works from walkway

Body & River

4.& 10. Downstream face (Spillway section) & Downstream protection works (Training walls)



11. Walkway

Observe in drainage & operation gallery

Gallery

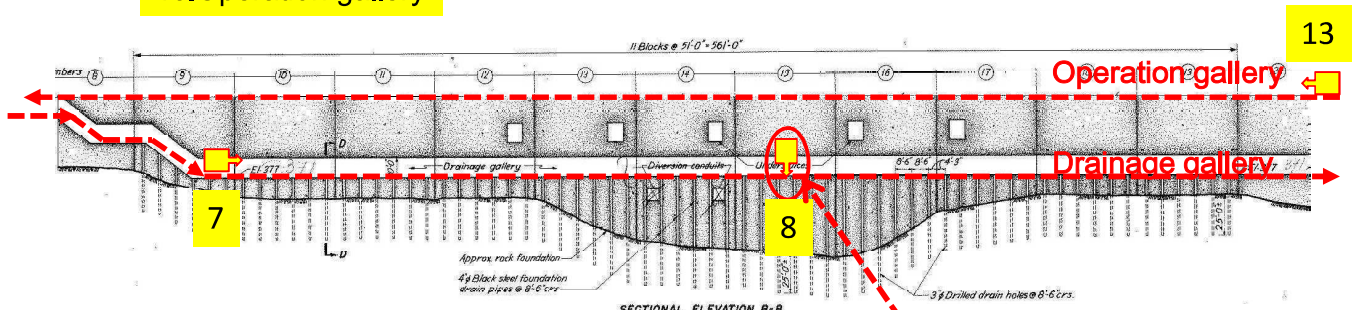


13. Operation gallery

Check crack
Volume of Leakage
Turbidity of Leakage

---> Inspection route

Viewpoint



7. Drainage gallery



Drain hole



8. Drain gutter

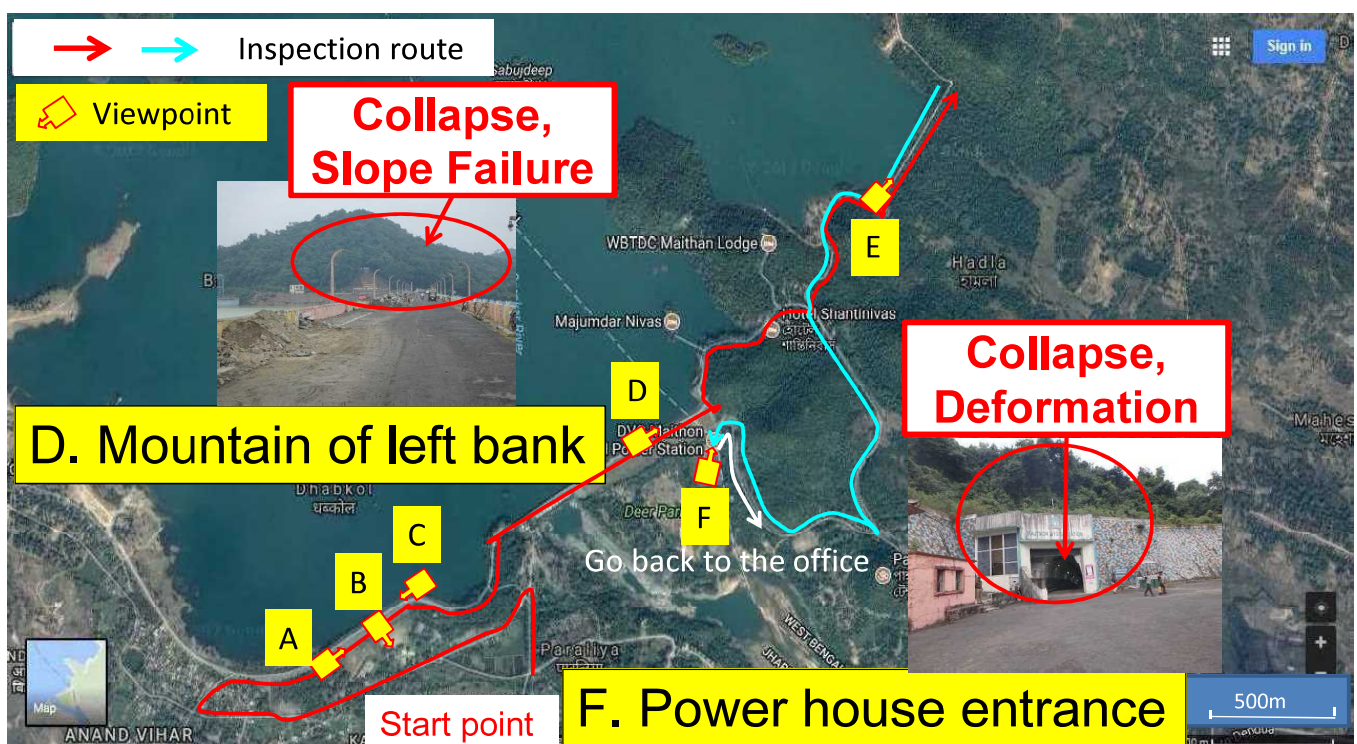


Drain hole for Mechanical Joint

First Inspection Route No.3

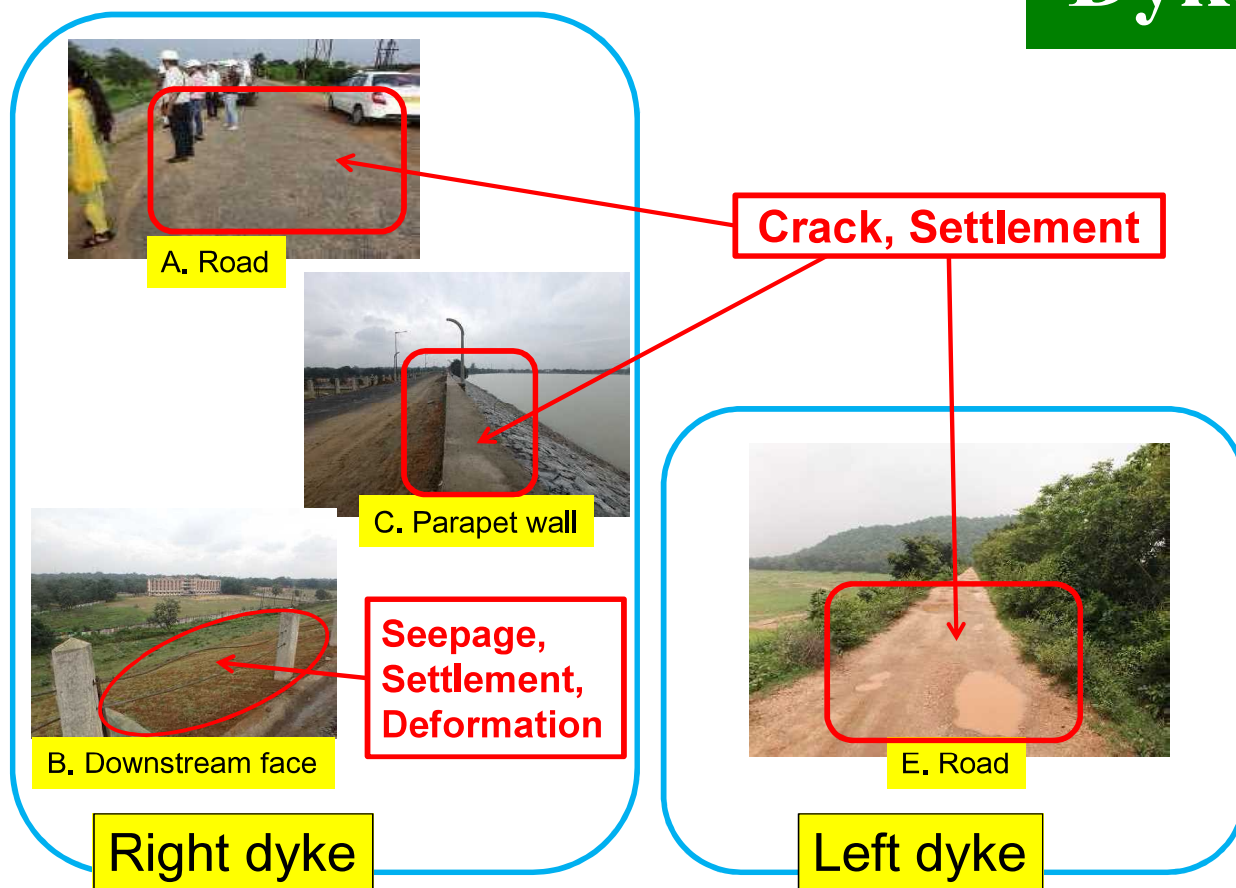
Civil C

Inspection route No.3 for First check (Civil C)



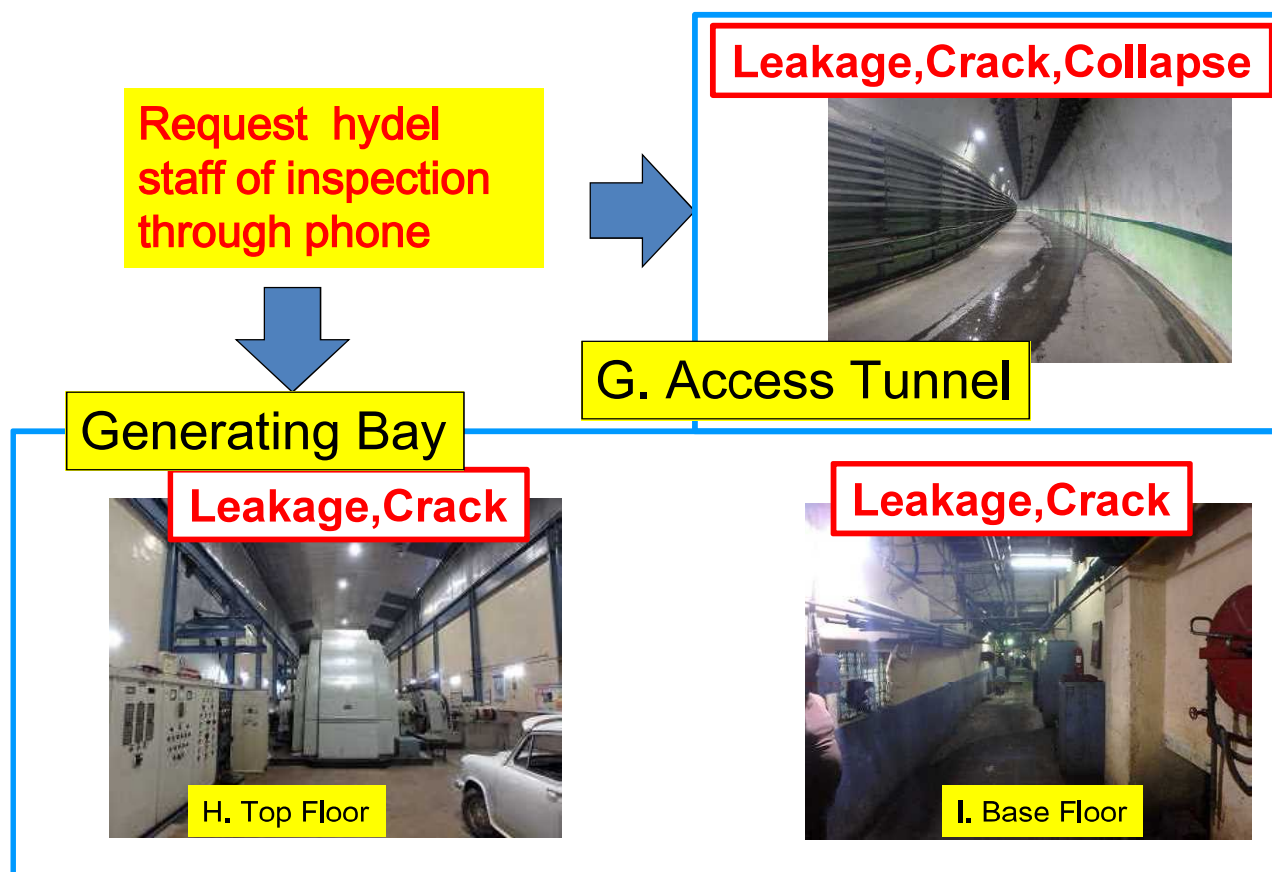
Observe downstream face and road from dyke

Dyke



Observe access and generating bay

Power house



Fill out reporting form and submit

Malith Darn
Checklist for extraordinary inspection (First Inspection)
Structures

Inspection time & date from _____ to _____
Name of inspector _____

	Structure	Check items	Status
Dam	Concrete Body	Upstream face	b Crack (visual) observe or camera)
		Downstream face (Spillway section)	d Leakages Crack (visual) observe or camera)
		Downstream face (Non-spillway section)	e Leakages Crack (visual) observe or camera)
		Operation Gallery	f Leakages Crack (visual) observe or camera)
		Drainage Gallery	g Leakages Crack (visual) observe or camera)
		Bridge	c Collapse, Deformation (visual) observe or camera)
Main Earth Dam		Compaction Line	e For Straight Alignment
		Upstream face	f Settlement, Deformation (visual) observe or camera)
		Downstream face	g Seepage, Settlement, Deformation (visual) observe or camera)
		Road Crest of Dam	h Crack, Settlement (visual) observe or camera)
		Parapet Wall	i Crack, Settlement (visual) observe or camera)
		Downstream face	B Seepage, Settlement, Deformation (visual) observe or camera)
River Dyke (adjacent to Malak Sudd)		Road	A Crack, Settlement (visual) observe or camera)
		Parapet Wall	C Crack, Settlement (visual) observe or camera)
		Left Dyke	E Crack, Settlement (visual) observe or camera)
Others		Proposed Control room	a Crack, any failure (visual) observe or camera)
		Intake Structure	J Crack, any failure (visual) observe or camera)
		Bridge (Access road to Intake Structure)	k Collapse, Deformation (visual) observe or camera)
		Maintenance Walkway	l Collapse, Deformation (visual) observe or camera)
			m

	Power House	Access	F	G	H	I	D
Around Reservoir	Entrance	Access Tunnel	F	G	H	I	D
		Top Floor	F	G	H	I	D
	Generating Bay	Base Floor	F	G	H	I	D
		Roundabout	Left bank	F	G	H	I
Road	Access Road	F	G	H	I	D	
	Downstream protection works : Training Wall	4, 10	Crack (visual) observe or camera)				

Fill in observed data

Report to HO of DVC

Report with Result of
Mech. and E&T
by E-mail to

Contact Person of DVC Head Office	
	Name Post No. E-mail

Report to CWC

Report with Result of

Mech. and E&T

by E-mail to

Contact Person of CWC	
	Name Post No. E-mail

Report to DDMA's

Report with Result of

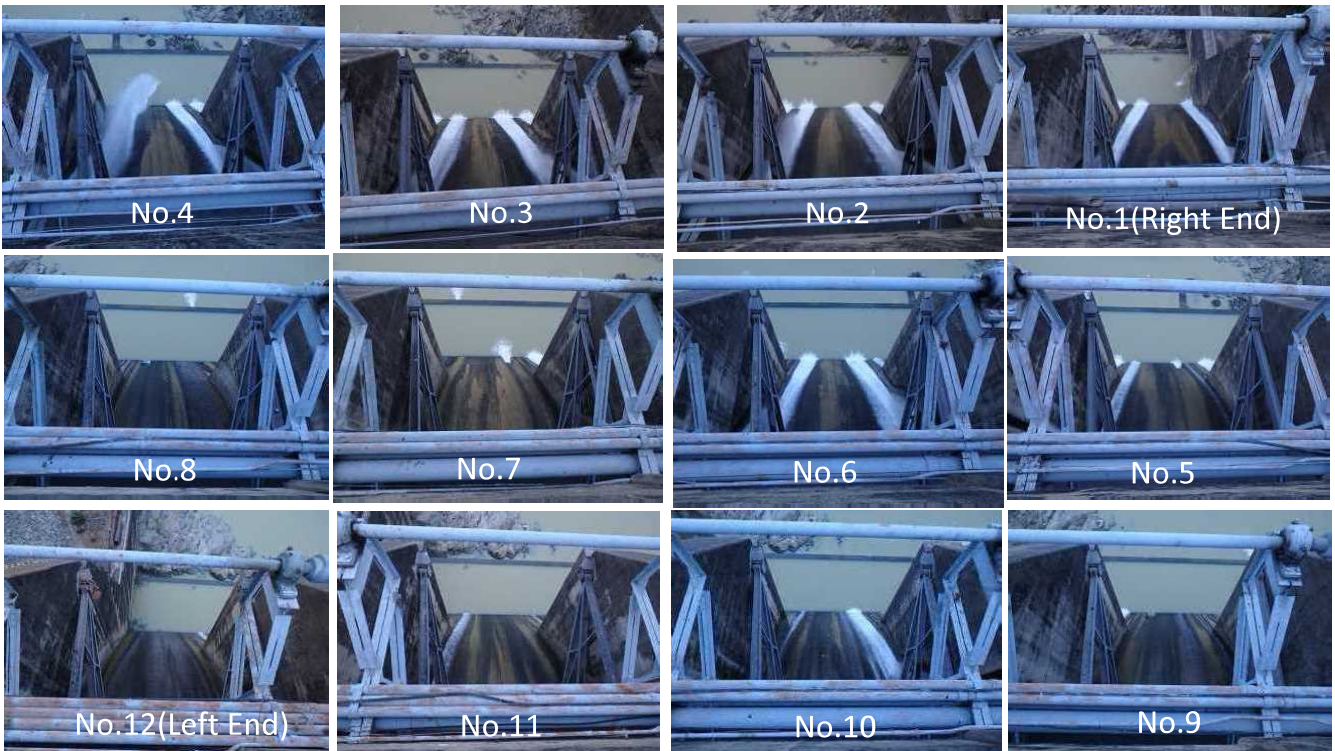
Mech. and E&T

by E-mail to

Contact Person of DDMA of West Bengal / Jharkand	
	Name Post No. E-mail

End

Appendix (Spillway section)





Draft

Manual

for Post-earthquake Inspection

First Inspection on Mechanical facilities

Maithon Dam

Ver. March.2018

Purpose of First Check

To urgently confirm the state of dam safety and mechanical, electric, information and communication facilities

Principle

- 1. After the Quick Check, the First Inspection shall be immediately started**
- 2. The report must be submitted to CWC and DVC HQ within 5hrs after earthquake**
- 3. Major check items are as follows**
 - control room, dam, dyke, power house, intake, river, around reservoir.**
 - mechanical, electric, information and communication facilities.**

Tools for inspection

- ✓ Writing kit
- ✓ Camera
- ✓ Mobile phone / Walkie-Talkie
- ✓ Helmet
- ✓ Keys
- ✓ Flashlight
- ✓ Checklist
- ✓ Manual

Checklist for extraordinary inspection (First Check)		
Inspection date: _____		
Name: _____		
Location of inspection: _____		
Item	Check	Result
1. Safety helmet	Worn correctly	Yes/No
2. Safety glasses	Worn correctly	Yes/No
3. Safety shoes	Worn correctly	Yes/No
4. Safety harness	Worn correctly	Yes/No
5. Safety net	Worn correctly	Yes/No
6. Safety belt	Worn correctly	Yes/No
7. Safety gloves	Worn correctly	Yes/No
8. Safety boots	Worn correctly	Yes/No
9. Safety vest	Worn correctly	Yes/No
10. Safety cap	Worn correctly	Yes/No
11. Safety glasses	Worn correctly	Yes/No
12. Safety shoes	Worn correctly	Yes/No
13. Safety harness	Worn correctly	Yes/No
14. Safety net	Worn correctly	Yes/No
15. Safety belt	Worn correctly	Yes/No
16. Safety gloves	Worn correctly	Yes/No
17. Safety boots	Worn correctly	Yes/No
18. Safety vest	Worn correctly	Yes/No
19. Safety cap	Worn correctly	Yes/No
20. Safety glasses	Worn correctly	Yes/No



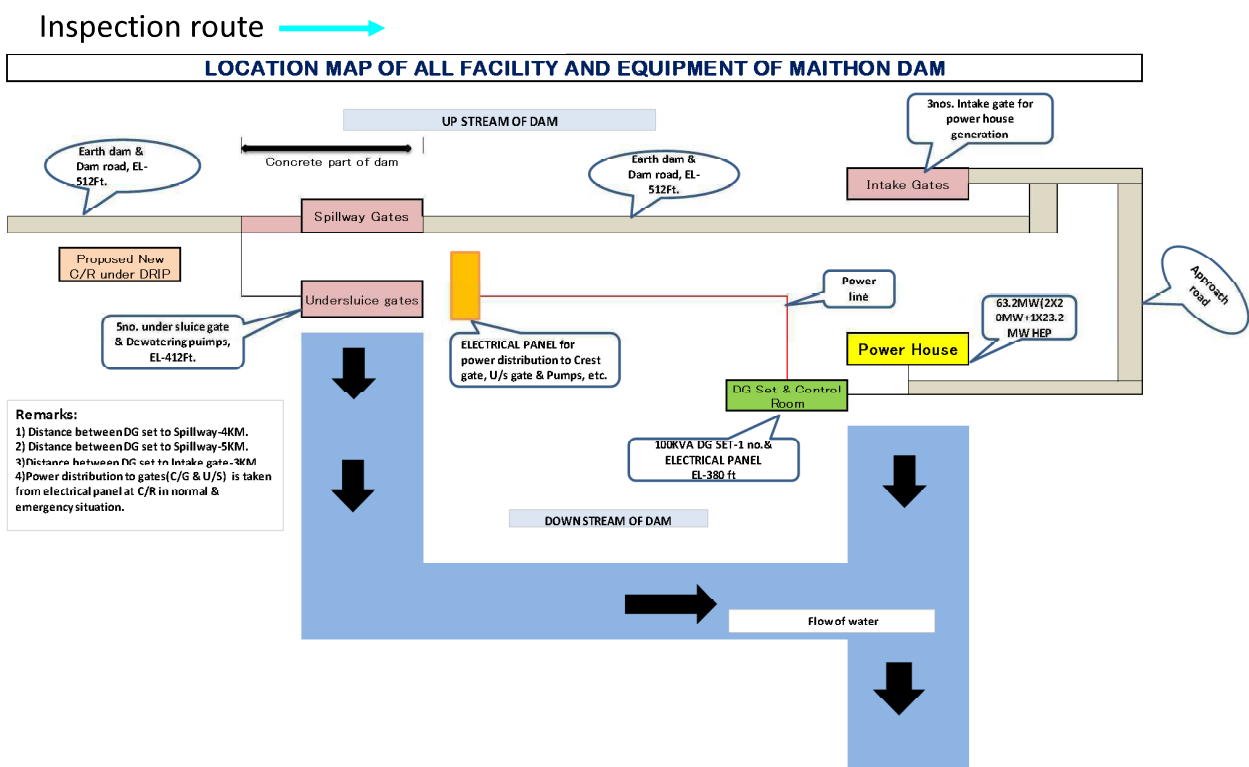
Route of the first check of Mechanical facilities

- Inspection route (Mech)
 - ✓ Spillway gates
 - ✓ Undersluice gates
 - ✓ Dewatering pumps

First Inspection Route

Mechanical facilities

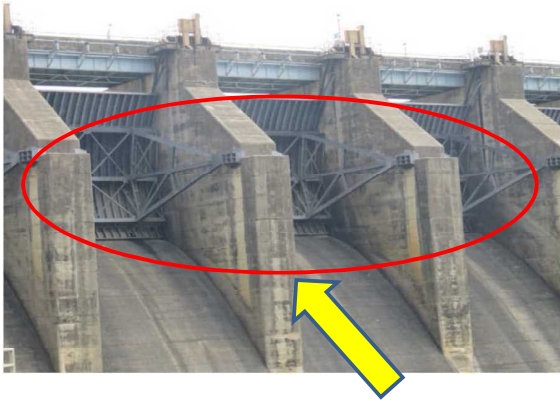
Inspection route for First check (Mechanical facilities)



Spillway gate – Check the status of gate 1 to 12

Body

Gate body and Seels



- Leak of Water from Gate (Abnormal volume of Water)
- Deformation (Gate body)



- Leak of Water from Gate (Abnormal volume of Water)
- Deformation (Trunnion, Leg Pillar)

Spillway gate – Check the status of gate 1 to 12

Body

Hoist foundation structure



- Crack, Deformation

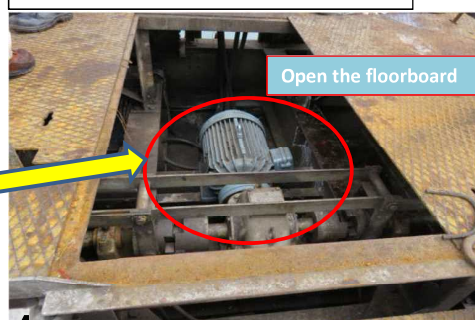
- Broken

- Leaning, Leak of oil

Lifting/Lowering chain



Hoist equipments



Under sluice gate – Check the status of gate 1 to 5

Body

Hoist foundation structure



Hoist(opening and closing) equipment



▪ Crack, Deformation

▪ Leaning, Leak of Oil
(check pont :Plumbing jont,Oil Gage)

Drainage gallery pump – Check the status of pump 1 & 2

Body



▪ Leaning



▪ Overflow water(Drainage wells)

Fill out reporting form and submit

Maithon Dam

Checklist for first inspection

Mechanical facilities

Location:- Maithon Dam, Distt-Dhanbad, Jharkhand-828207

Implementation

Date

Time

by Date

Time

Name

Name of Equipment	Check Item	Procedure	State																						Reference
			Spillway Gate												Under Sluice Gate					Pump					
			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#1	#2	#3	#4	#5	#1	#2				
Gates	Hoist foundation structure	Crack, Deformation	Visual Check																						
	Gate body and seals	Deformation	Visual Check																						
		Leakage	Visual Check																						
	Hoist (Opening and closing) Equipment	Leaning	Visual Check																						
		Leak of oil	Visual Check																						
	Lifting/Lowering chain	Broken	Visual Check																						
	Trunnion	Deformation	Visual Check																						
	Drainage Gallery pump	Leaning	Visual Check																						

Remark

Fill in result of check

End



Draft

Manual

for Post-earthquake Inspection

First Inspection on Electric and Telecommunication Facilities

Maithon Dam

Ver. March.2018

Purpose of First Check

To urgently confirm the state of dam safety and mechanical, electric, information and communication facilities

Principle

- 1. After the Quick Check, the First Inspection shall be immediately started**
- 2. The report must be submitted to CWC and DVC HQ within 5hrs after earthquake**
- 3. Major check items are as follows**
 - control room, dam, dyke, power house, intake, river, around reservoir.**
 - mechanical, electric, telecommunication and information facilities.**

Tools for inspection

- ✓ Writing kit
- ✓ Camera
- ✓ Mobile phone / Walkie-Talkie
- ✓ Helmet
- ✓ Keys
- ✓ Flashlight
- ✓ Checklist
- ✓ Manual

Inspection		Inspection Date	Inspector
Checklist for preliminary inspection (Pre-Check)			
1. General	2. Specific	3. Remarks	4. Signature
1.1. Safety	1.1.1. Safety gear		
1.2. Access	1.2.1. Access route		
1.3. Weather	1.3.1. Weather condition		
1.4. Time	1.4.1. Time of day		
1.5. Location	1.5.1. Location of inspection		
1.6. Personnel	1.6.1. Personnel involved		
1.7. Equipment	1.7.1. Equipment used		
1.8. Other	1.8.1. Other information		
2.1. Structure	2.1.1. Structure condition		
2.2. Foundation	2.2.1. Foundation condition		
2.3. Water level	2.3.1. Water level		
2.4. Flow rate	2.4.1. Flow rate		
2.5. Sediment	2.5.1. Sediment condition		
2.6. Other	2.6.1. Other information		



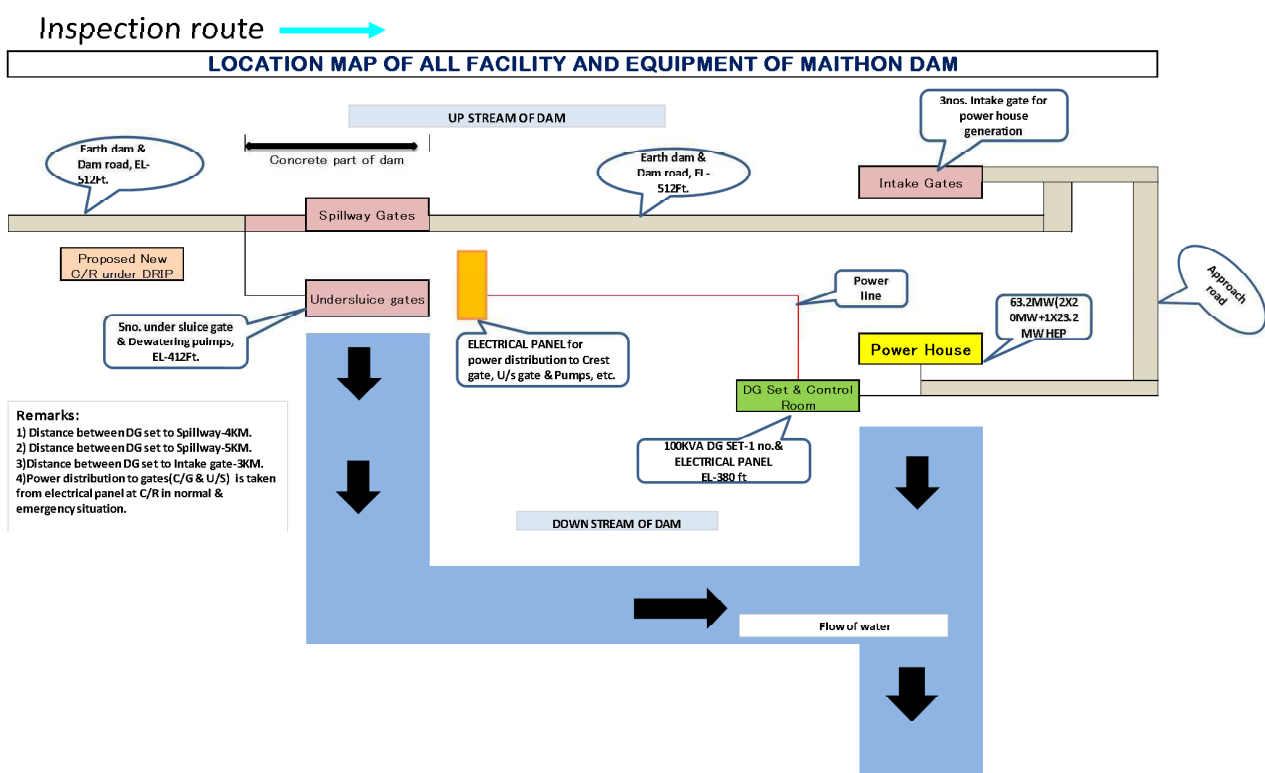
Route of the first check of Electric, Telecommunication and Information facilities

- Inspection route (Electric, Telecommunication and Information facilities)
 - ✓ Communication equipments
 - ✓ Power supply
 - ✓ Emergency generator
 - ✓ Fuel tank of emergency generator
 - ✓ Operation board for emergency generator
 - ✓ Local operation board for crest gate
 - ✓ Local operation board for under sluice gate
 - ✓ Local operation board for dewatering pumps in dam gallery

First Inspection Route

Electric, Telecommunication and Information facilities

Inspection route for First check (Electric, Telecommunication and information facilities)



Communication equipment – Check the status

Office

Cable phone



Put a call in to another telephone in office

voice call check (Cable line)
(* * * - * * * *) to intended party
(* * * - * * * *) voice call check

Mobile phone



Put a call in to another telephone in office

voice call check
(* * * - * * * *) to intended party
(* * * - * * * *) voice call check

Electric power receiving and transforming equipment – Check the status

ACDB

Power supply



Measuring
data check
(normal /
abnormal)

Electric power receiving and transforming equipment – Check the status

DGroom

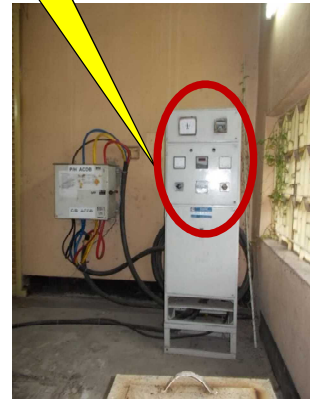
Emergency generator



Leaning , Broken,
Crack of floor, Leak of
oil , Liquid on the
floor

Measuring
data check
(normal /
abnormal)

Operation board
for emergency
generator



Fuel tank



Leaning , Broken,
Crack of floor,
Leak of oil , Liquid
on the floor,
Quantity of Fuel

Leaning , Broken,
Liquid on the
floor

Radiator



Crest gate – Check the status

Body

Local operation board



Measuring data
(normal / abnormal)

Leaning
(normal /
abnormal)

Lighting position
(normal /
abnormal)

Lighting around gate
hoist (normal/
abnormal)

Under sluice gate – Check the status

Body

Local operation board



Measuring data
(normal / abnormal)

Leaning
(normal /
abnormal)

Lighting position
(normal /
abnormal)

Drainage gallery pump – Check the status

Body

Local operation board



Measuring data
(normal / abnormal)

Leaning
(normal /
abnormal)

Lighting position
(normal /
abnormal)

Fill out reporting form and submit

Maithon Dam
Checklist for first inspection
Electric, Telecommunication and information facilities
Location:- Maithon Dam, Dist-Dhanbad, Jharkhand-828207

Inspectoin time & date
from : / / to : / /

E,TC,I	Check items		Procedure	Check	Crest gate(12 nos.)												Under sluice gate (5 nos.)					Remarks
					1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	
Communication Equipment	Mobile communication equipment		call	Voice Check																		In C/R
	Cable communication		call	Voice Check																		In C/R
Electric power receiving and transforming equipment	Power supply		measuring data check (normal/abnormal)	Visual Check																		In Main ACDB near C/R
	Emergency generator system	Emergency generator	check status (leaning, broken, Crack of floor, leak of oil, liquid on the floor) and Test run	Visual Check & Test run																		In DG Room
		Fuel tank	check status (leaning, broken, Crack of floor, leak of oil, liquid on the floor, fuel)	Visual Check																		In DG Room
		Radiator	check status (leaning, broken, liquid on the floor)	Visual Check																		In DG Room
		Operation board	measuring data check (normal/abnormal)	Visual Check																		In DG Room
Electrical Equipment	Remote operation Board		check status (display/panel)	Visual Check																		In Future
	Observational equipment (water level, rainfall etc.)		check status (display, record)	Visual Check																		In Future
	Monitoring camera		check status (display/panel)	Visual Check																		In Future
	Local operation Board		check status (leaning, measuring data, lighting position, lighting arround gate hoist)	Visual Check																		Each gate site
Drainage Gallery Pump	Local operation Board for dewatering pumps in Dam Gallery		check status (leaning, measuring data, lighting position)	Visual Check																		Near Pump

Remarks:

Fill in result of check

End

Appendix 4 Drill scenario

**The Consultancy Service for the Preparation of
Inspection Manual for Dam Field Engineers
after Seismic Events**

Mock Drill Scenario

March. 2018

Incorporated Administrative Agency
Japan Water Agency (JWA)

Abbreviations

MoWR:	Ministry of Water Resources, River Development & Ganga Rejuvenation
CWC:	Central Water Commission
DVC:	Damodar Valley Corporation
MTD:	Maithon Dam
MTD-AO:	Maithon Dam Administrative Office
DVC-HO:	DVC Head Office
IMD:	Indian Meteorological Department
DDMA:	District Disaster Management Authority
DRH:	Disaster Response Headquarters
Exec Dir.:	Executive Director
Chief Eng.:	Chief Engineer
Dy. Chief Eng.:	Deputy Chief Engineer
Exec Eng.:	Executive Engineer
Asst Eng.:	Assistant Engineer
Jr. Eng.:	Junior Engineer

1. Objective

1. Once a significant earthquake happens, people will be in panic and hard to exchange damage information correctly. Not only physical damage such as power failure and road cut off but also concentration of telephonic communication may cause secondary trouble which sometimes leads to critical situation.
2. On the other hand, a dam with massive stored water is one of the structures which we should caution about when a significant earthquake occurs. Avoiding or minimizing any human and economic damages in lower reach is a race against time. In order to collect and disseminate necessary information about the damage of the dam even in a panic situation and make a decision for subsequent actions immediately and appropriately, it is essential to establish some scheme to work systematically.
3. The earthquake response manuals and checklists can support this systematic work, but it is necessary to be revised continuously incorporating social requirement, lessons learned from past experiences, and progress of technology.
4. The immediate objective of this mock drill is to familiarize earthquake response to all the persons concerned by following the scenario. After the mock drill, all the manuals and checklists will be upgraded by incorporating feedbacks from the drill results. Through this practice, it is expected that the idea of immediate and appropriate response to earthquakes on dams will be spread and further developed in India.

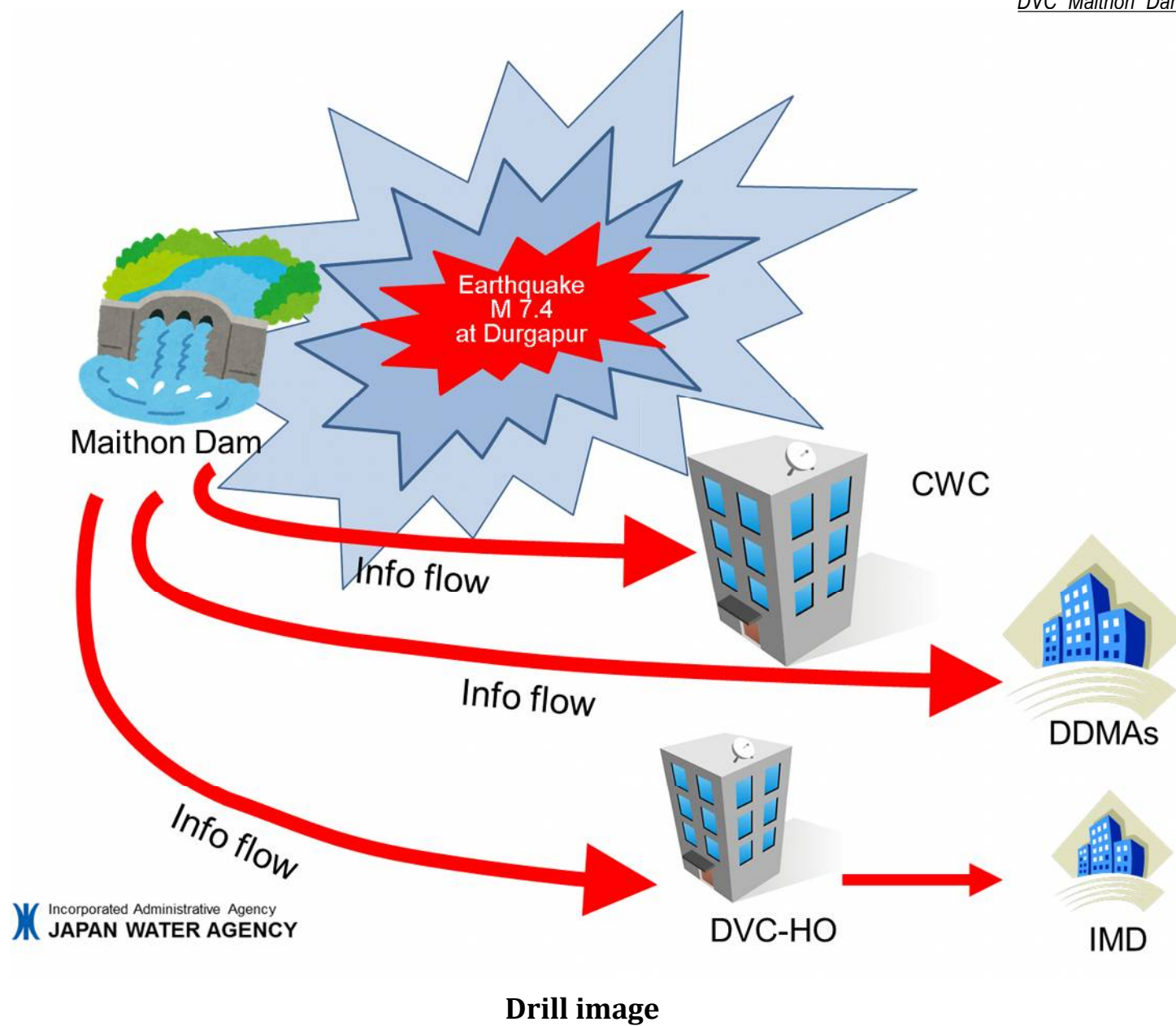
2. Drill outline

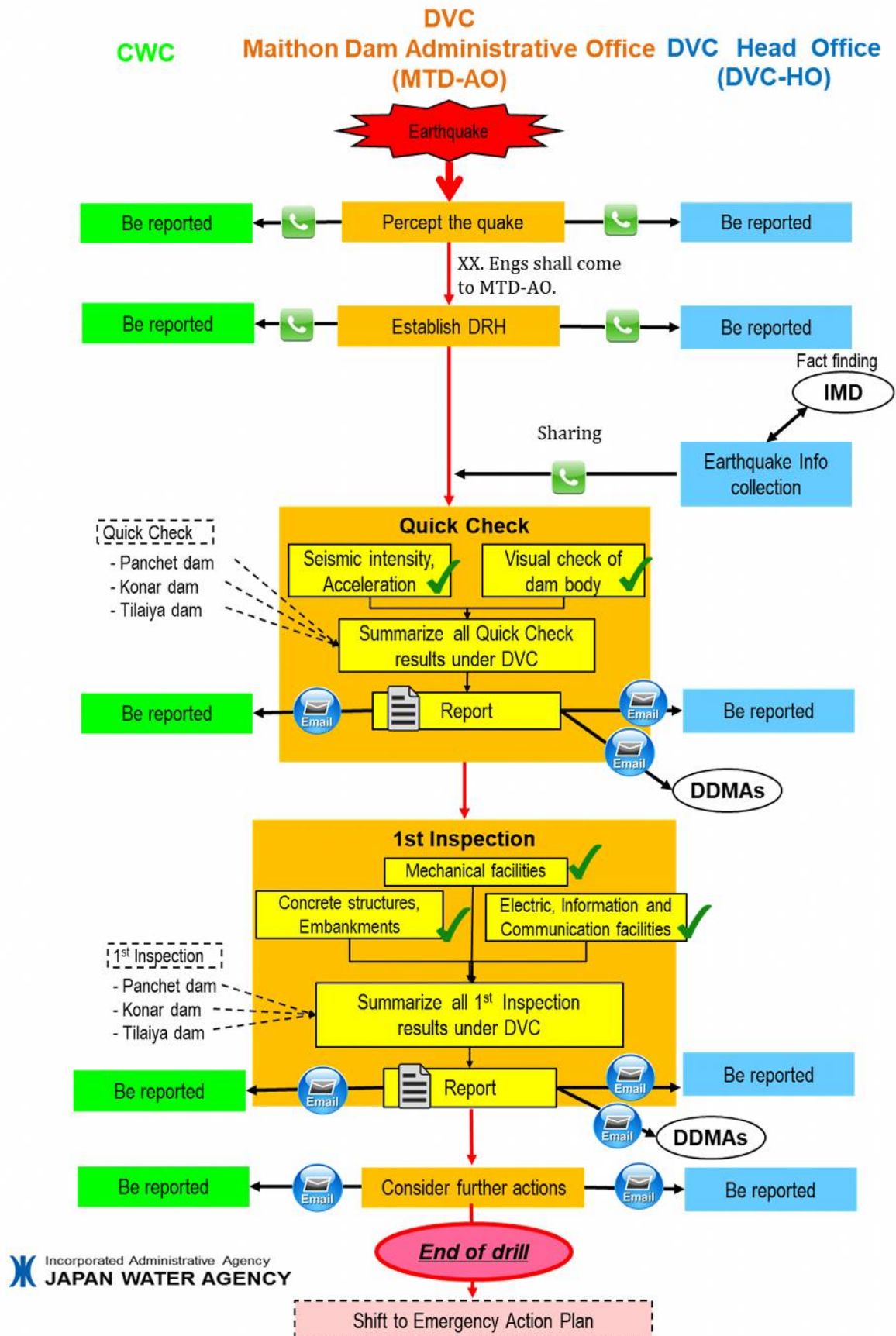
Date: 14th March 2018

Venue: Maithon Dam (MTD), DVC Head Office(DVD-HO) and the other relevant entities

Participants: Officials of CWC, DVC, Maithon Dam, and Japan Water Agency

Assumption: This earthquake occurs on a holiday and some Jr.Eng(s) and operators are working at Maithon Dam. Most of the other staff members stay near Maithon Dam.





Drill flow

3. Drill Scenario

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
10:00	M7.4, the epicenter at Durgapur (60 km from Maithon Dam)	-		
10:05	<p>Jr. Eng. at MTD-AO reports to Exec Eng. of MTD that he felt a strong quake just now.</p> <p><i>"This is drill. I felt a strong quake just now. Currently, 20? staff members are on duty, but their safeties have not yet been confirmed."</i></p> <p><i>Re: "I got it. I will come to Maithon Dam Administrative Office (MTD-AO) about 15 minutes."</i></p> <p>All staff members concerned need to come to the MTD-AO voluntarily after confirming their families' safety. Then, staff members in the office will confirm safeties of all their colleagues whose safeties are unknown.</p>	<p>MTD-AO Jr. Eng. (Saurav Maity)</p>	<p>MTD-AO Exec Eng. (Sanjeev Kumar)</p>	<p>Staff members to come to MTD-AO after a strong earthquake should be decided previously.</p> <p>The staff members should voluntarily come to MTD-AO immediately when they feel a strong earthquake.</p>
10:07	<p>The Exec Eng. of MTD calls Dy. Chief Eng. of MTD.</p> <p><i>"This is drill. There seems to have been a significant earthquake at Maithon Dam. Please come to Maithon Dam immediately. I am heading to MTD-AO now and will arrive within 15 minutes."</i></p> <p><i>Re: " Okay. I am in my house now and can get to MTD-AO around 15 minutes as well. "</i></p>	<p>MTD-AO Exec Eng. (Sanjeev Kumar)</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
10:10	<p>Dy. Chief Eng. of MTD reports the situation to DVC Head Office (DVC-HO).</p> <p><u>This is drill.</u> <i>I was reported that there had been a significant quake at Maithon Dam. I also felt it at my house. I am getting to MTD-AO about 15 minutes.</i></p> <p><i>Re: "I got it. Keep me updated."</i></p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>DVC-HO Dy. Chief Eng. (S. B. Pandey)</p>	
10:12	<p>Dy. Chief Eng. of MTD-AO reports the situation to CWC</p> <p><u>This is drill.</u> <i>I was reported that there had been a significant quake at Maithon Dam. I also felt it at my house. I am getting to MTD-AO about 15 minutes.</i></p> <p><i>Re: "I got it. Keep me updated."</i></p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>CWC Project Director, DRIP (Pramod Narayan)</p>	
10:15	<p>Dy. Chief Eng. of MTD-AO arrives at MTD-AO and reports the establishment of Disaster Response Headquarters (DRH) to DVC-HO.</p> <p><u>This is drill.</u> <i>I just arrived at MTD-AO and Emergency Disaster Response Headquarters (DRH) at MTD-AO has been established.</i></p> <p><i>Re: " Okay. We will contact IMD to collect earthquake information and get back to you."</i></p> <p><i>" Okay."</i></p> <p>Then Exec Eng. arrives at MTD-AO, too.</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>DVC-HO Dy. Chief Eng. (S. B. Pandey)</p>	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
10:17	<p>Dy. Chief Eng. of MTD-AO reports the establishment of Disaster Response Headquarters (DRH) to CWC.</p> <p><u>This is drill.</u> <i>I just arrived at MTD-AO and Emergency Disaster Response Headquarters (DRH) at MTD-AO has been established. The emergency inspections will be carried out accordingly."</i></p> <p>Re: "Okay."</p> <ul style="list-style-type: none"> ➤ The Disaster Response Headquarters (DRH) has been established at MTD-AO. After that, all information is sent to Exec Dir., and DRH members are required to work following the instruction of Exec Dir. in principle. ➤ The image of DRH is in the last page of this document. 	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>CWC Project Director, DRIP (Pramod Narayan)</p>	
10:20	<p>Dy. Chief Eng. instructs Exec Eng(s):</p> <ul style="list-style-type: none"> • To check safeties of all staff members 	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>MTD-AO Executive Eng. (N S Kumari)</p>	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
10:25	<p>Dy. Chief Eng. instructs Exec Eng(s):</p> <ul style="list-style-type: none"> To instruct implementation of Quick Check. <p>The MTD staff members are to be divided into three teams (but it is up to availability of Asst and Jr. Eng(s))</p> <ul style="list-style-type: none"> i)The responsible person for reporting ii)The responsible person for seismometer iii)The responsible person for MTD outlook check <p>Then, each person picks up the manual, the checklist and the required tools.</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>MTD-AO Exec Eng(s) i) (N S Kumari) ii) (Sanjeev Kumar) iii)(Suresh Chandra Sirgh)</p>	
10:30	<p>Desktop DVC-HO contacts to IMD.</p> <p><i>“This is drill. This is DVC-HO. For securing safety of our power generating facilities, please let us know the detail of earthquake occurred a while ago.</i></p> <p><i>Re: “Its magnitude was 7.4 and the epicenter was around Durgapur. You must be careful about aftershocks which might continuously attack as the same level of previous one at least one week.</i></p>	<p>DVC-HO Dy. Chief Eng. (S. B. Pandey)</p>	<p>IMD ***** (***** ***)</p>	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
10:35	<p>DVC-HO informs to MTD-AO about the earthquake.</p> <p><i>"This is drill. According to the IMD, the earthquake was 7.4 magnitude and the epicenter was around Durgapur. They advised us to be careful about aftershocks which might continuously attack as the same level of previous one at least one week."</i></p> <p><i>Re: "I understand. We will take emergency action avoiding secondary damage."</i></p>	<p>DVC-HO Dy. Chief Eng. (S. B. Pandey)</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	
10:40	<p>The check of safeties of all the staff members is completed.</p> <p><i>"This is drill. The safety of all staff members had been confirmed."</i></p> <p><i>Re: "Okay."</i></p>	<p>MTD-AO Executive Eng. (N S Kumari)</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
10:45	<p>The draft Quick Check report has been completed, and Exec Eng. at MTD-AO requests Dy. Chief Eng. to confirm the report contents and send it to DVC-HO and CWC by e-mail.</p> <p><u>This is drill.</u> We've completed the Quick Check, so please look through the results. Up to now, no severe damage was observed to the Maithon Dam."</p> <p>Re: "Okay."</p> <p>The results of the Quick Check are shown below.</p> <ul style="list-style-type: none"> ✓ Acceleration: X: 100 cm/sec²(=100gal) Y: 110 cm/sec²(=110gal) Z: 30 cm/sec²(=30gal) ✓ Seismic Intensity: VIII (MSK scale) : Refer to the table on the last page ✓ No severe damages on the roads at the Dam site at the first sight ✓ No damages on the dam body at the first sight 	MTD-AO Executive Eng. (N S Kumari)	MTD-AO Dy. Chief Eng. (Rabindra Kumar)	
10:50	<p><u>This is drill.</u> We've sent the Quick Check report on Maithon Dam by e-mail just now. Please let me confirm to be sure its arrival."</p> <p>Re: "We've received it."</p>	MTD-AO Dy. Chief Eng. (Rabindra Kumar)	DVC-HO Dy. Chief Eng. (S. B. Pandey)	
10:52	<p><u>This is drill.</u> We've sent the Quick Check report on Maithon Dam by e-mail just now. Please let me confirm to be sure its arrival."</p> <p>Re: " We've received it."</p>	MTD-AO Dy. Chief Eng. (Rabindra Kumar)	CWC Project Director, DRIP (Pramod Narayan)	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
10:55	Desktop Dy. Chief Eng. at MTD-AO submits the Quick Check report to DDMA in Jharkhand State after checking its contents. <i>"This is drill. I've sent the Quick Check report to DDMA by e-mail just now. Please let me confirm to be sure its arrival"</i> <i>Re:" We've received it."</i>	MTD-AO Dy. Chief Eng. (Rabindra Kumar)	DDMA in Jharkhand State ***** (**** *)	
10:57	Desktop Dy. Chief Eng. at MTD-AO submits the Quick Check report to DDMA in West Bengal State after checking its contents. <i>"This is drill. I've sent the Quick Check report to DDMA by e-mail just now. Please let me confirm to be sure its arrival"</i> <i>Re:" We've received it."</i>	MTD-AO Dy. Chief Eng. (Rabindra Kumar)	DDMA in West Bengal State ***** (**** *)	
11:00	Dy. Chief Eng. at MTD-AO instructs Exec Eng(s) to begin the first inspection. The MTD staff members are to be divided into four teams (but it is up to availability of Asst and Jr. Eng(s)) i)The team for reporting ii)The team for structural inspection iii)The team for mechanical inspection iv)The team for electric, information and communication inspection Each team picks up the manual, the checklist and the required tools.	MTD-AO Dy. Chief Eng. (Rabindra Kumar)	MTD-AO Exec Eng(s) i) N.S. Kumari ii) Sanjeev Kumar Suresh Chandra Sirgh Atul Kumar iii) R. K. Nayak iv) Suresh Chandra Singh	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
11:40	<p>The 4 teams as followed come back to MTD-AO after the inspections.</p> <p>i)The team for reporting ii)The team for structural inspection iii)The team for mechanical inspection iv)The team for electric, information and communication inspection</p> <p>Each team reports an overview of the inspection result to Dy. Chief Eng. orally.</p>	<p>MTD-AO Exec Eng(s) i) N.S. Kumari ii) Sanjeev Kumar Suresh Chandra Sirgh Atul Kumar iii) R. K. Nayak iv) Suresh Chandra Singh</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	
11:45	<p>Exec Eng(s) of the 4 teams as followed make the first inspection reports and submits them to Dy. Chief Eng.</p> <p>i)The team for reporting ii)The team for structural inspection iii)The team for mechanical inspection iv)The team for electric, information and communication inspection</p> <p>Dy. Chief Eng. confirms the contents of the first inspection reports.</p>	<p>MTD-AO Exec Eng(s) i) N.S. Kumari ii) Sanjeev Kumar Suresh Chandra Sirgh Atul Kumar iii) R. K. Nayak iv) Suresh Chandra Singh</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	

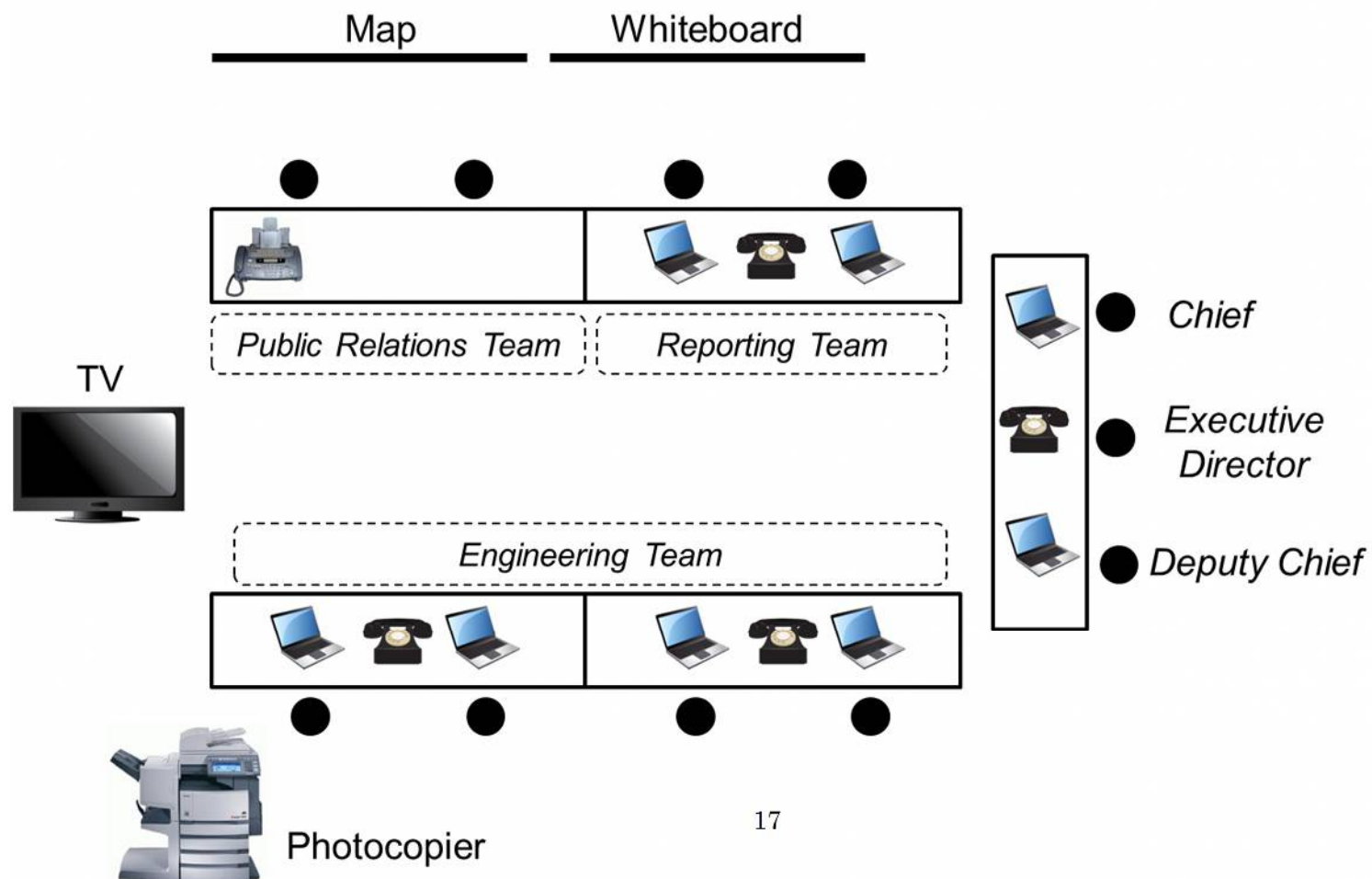
Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
11:50	<p>The first inspection report is sent to DVC-HO.</p> <ul style="list-style-type: none"> ✓ Leakage in the drain gutter of drainage gallery seems to have increased. Nothing turbid in the leakage water. ✓ Also leakage from a crest gate seems to have increased. ✓ A part of parapet wall of the embankment dam crest was deformed slightly. ✓ No damage on the dam body and spillway gates and electric systems. <p><i>"This is drill. I sent the First Inspection report by e-mail just now. Please let me confirm its arrival"</i></p> <p><i>Re: "We received and I am looking through it now."</i></p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>DVC-HO Dy. Chief Eng. (S.B.Pandey)</p>	<p>In the real case, the MTD-AO collects information of all dams under DVC and sends it.</p>

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
11:52	<p>The first inspection report is sent to CWC.</p> <ul style="list-style-type: none"> ✓ Leakage in the drain gutter of drainage gallery seems to have increased. Nothing turbid in the leakage water. ✓ Also leakage from a crest gate seems to have increased. ✓ A part of parapet wall of embankment dam crest was deformed slightly. ✓ No damage on the dam body and spillway gates and electric systems. <p><i>"This is drill. I sent the First Inspection report by e-mail just now. Please let me confirm to be sure its arrival"</i></p> <p><i>Re: "We received it. We'll check it.</i> <i>By the way, water level of Maithon Dam has not reached to CWC system. It might be some problem happened on the gauge or telecommunication line. So please let me ask you to provide MTD water level data twice a day such as 10 o'clock am and 4 o'clock pm for the time being."</i></p> <p><i>T: "Okay. We will do as you requested."</i></p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>CWC Project Director, DRIP (Pramod Narayan)</p>	<p>In the real case, the MTD-AO collects information of all dams under DVC and sends out.</p>
11:54	<p>Desktop Dy. Chief Eng. at MTD-AO submits the First Inspection report to DDMA in Jharkhand State by e-mail after checking the contents.</p> <p><i>"This is drill. I sent the First Inspection report to DDMA in Jharkhand State by e-mail just now. Please let me confirm to be sure its arrival."</i></p> <p><i>Re: "We received it."</i></p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>DDMA in Jharkhand State ***** (**** *)</p>	

Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
11:56	<p>Desktop Dy. Chief Eng. at MTD-AO submits the First Inspection report to DDMA in West Bengal State by e-mail after checking the contents.</p> <p><i>"This is drill. I sent the First Inspection report to DDMA in West Bengal State by-email just now. Please let me confirm its arrival."</i></p> <p>Re: "We received it."</p>	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>DDMA in West Bengal State ***** (***** *)</p>	
12:00	<p>Dy. Chief Eng. instructs Exec Eng(s) to</p> <ul style="list-style-type: none"> ✓ Measure the leakage volume at the weir and compare it with the ordinary volume. ✓ Confirm whether the gates can work with setting the guard gates. ✓ Survey the horizontal deformation and the settlement of the dam body and crest. 	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>MTD-AO Exec Eng(s) i) N.S. Kumari ii) Sanjeev Kumar Suresh Chandra Sirgh Atul Kumar iii) R. K. Nayak iv) Suresh Chandra Singh</p>	<p>It is highly recommended that a weir in the drain gutter to measure leakage will be installed and periodic measurement will be done.</p>
12:05	<p>After a while.</p> <p>Dy. Chief Eng. instructs Exec Eng(s) to</p> <ul style="list-style-type: none"> ✓ Prepare the gate operation test, and carry out it in consideration of the leakage in the gallery and aftershocks. ✓ Check twice a day whether there are any changes in all the gates and the leakage volume at weir. 	<p>MTD-AO Dy. Chief Eng. (Rabindra Kumar)</p>	<p>MTD-AO Exec Eng(s) i) N.S. Kumari ii) Sanjeev Kumar Suresh Chandra Sirgh Atul Kumar iii) R. K. Nayak iv) Suresh Chandra Singh</p>	

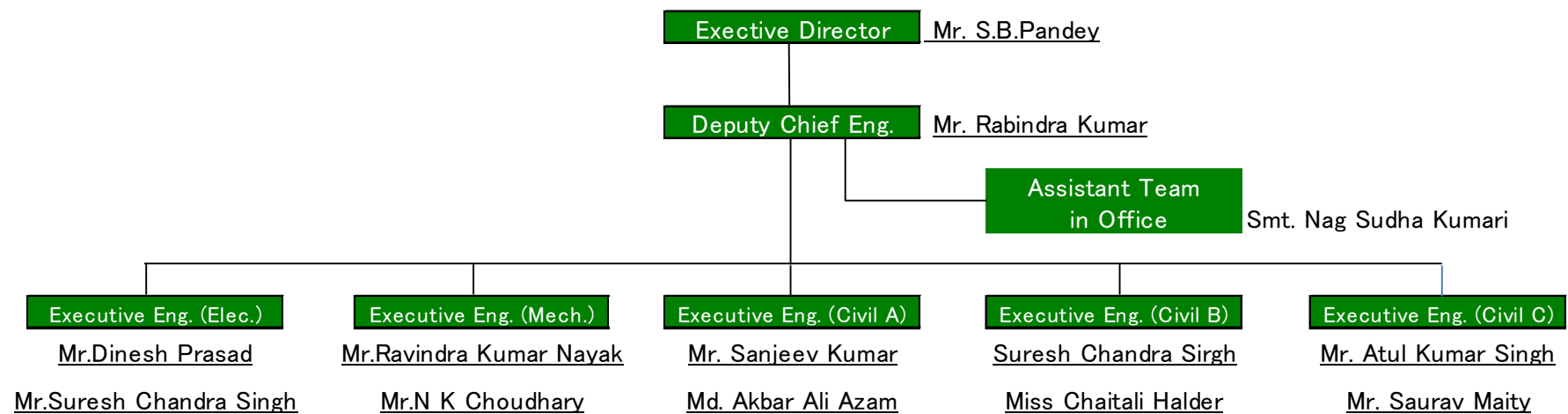
Drill schedule	Events and actions	Report from who to whom		Discussion point
		From	To	
12:15	A feedback meeting at MTD-AO	-		

Layout – Maithon Dam Disaster Response Headquarters





Disaster response headquarters image


Organization Chart of Maithon Dam Administrative Office



MSK-s: Medvedev-Sponheuer-Kárník scale


Intensity No.	Intensity name	Comment
I	Not perceptible	
II	Hardly perceptible	
III	Weak	
IV	Largely observed	
V	Fairly strong	
VI	Strong	<p>This is the threshold for taking the emergency action in dams' offices in Japan.</p> 
VII	Very strong	
VIII	Damaging	<p>Assumed earthquake in this drill</p> 
IX	Destructive	
X	Devastating	
XI	Catastrophic	
XII	Very catastrophic	

Appendix 5 Presentation material on Recommendation



Recommendations from JWA's Experiences

Incorporated Administrative Agency
JAPAN WATER AGENCY (JWA)



trust funded and administrated by THE WORLD BANK

Fuel in emergency power generator

72 hrs

Japan Water Agency












Japan Water Agency

Power backup

1 unit with 12hrs

2 unit with 72hrs

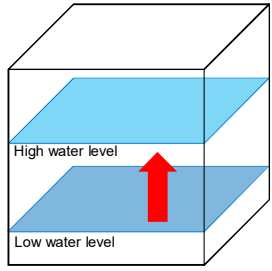
4

Monitoring leakage and drainage




Japan Water Agency

Alternate



20:30 pump start

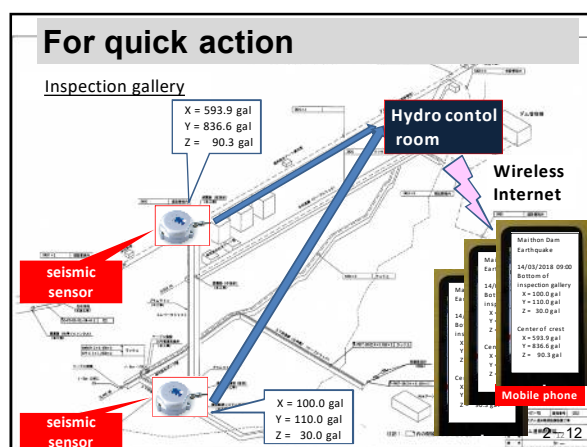
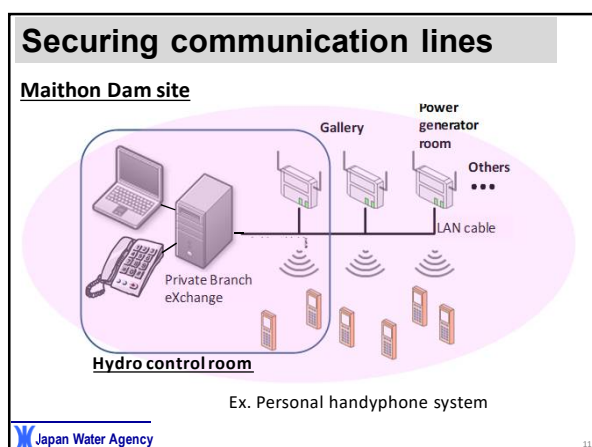
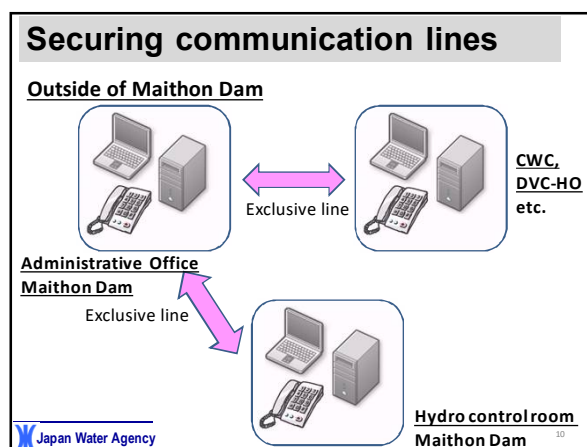
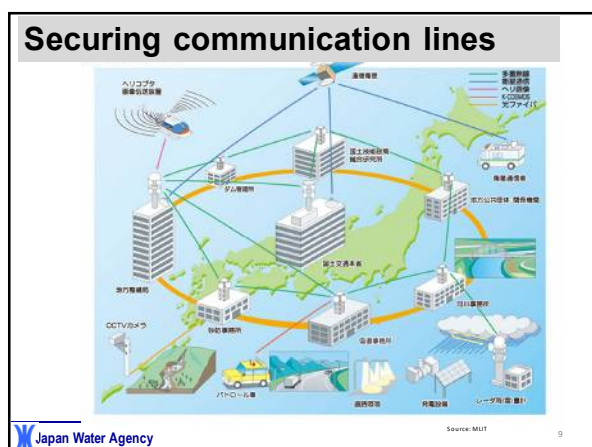
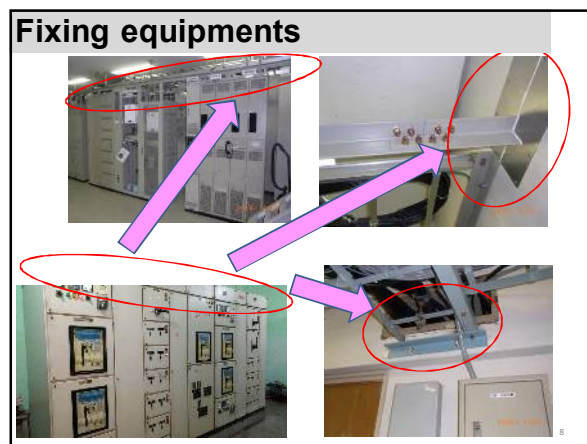
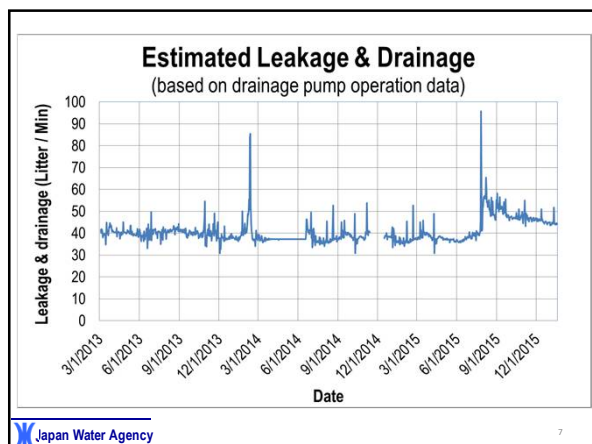
t = Interval of pump operation

V = Scale of pit between HWL and LWL

10:00 pump stop

Total leakage & drainage = V/t

Japan Water Agency



Specification of seismic sensor (example)

Example of Specification

Measurement component: 3 (horizon 2, vertical 1)
 Maximum acceleration: $\pm 2,000$ gal and over
 Transmission distance: 500m (seismic sensor - optical transmitter)
 Water proof : IPX6 and over
 Electric power: from optical transmitter
 Arrestor: Internal

Image



Display of mobile phone

Report to Dam
Manager
in real time

Maithon Dam
Earthquake
14/03/2018 09:00

Bottom of
inspection gallery

X = **100.0** gal

Y = **110.0** gal

Z = **30.0** gal

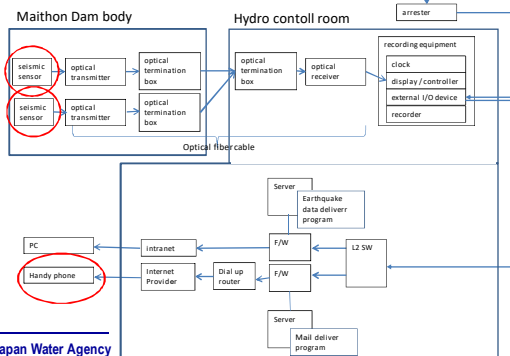
Center of crest

X = **593.9** gal

Y = **836.6** gal

Z = **90.3** gal

Earthquake information system



Thank you.



Central Dam Safety Organisation

Central Water Commission

Vision

To remain as a premier organisation with best technical and managerial expertise for providing advisory services on matters relating to dam safety.

Mission

To provide expert services to State Dam Safety Organisations, dam owners, dam operating agencies and others concerned for ensuring safe functioning of dams with a view to protect human life, property and the environment.

Values

Integrity: Act with integrity and honesty in all our actions and practices.

Commitment: Ensure good working conditions for employees and encourage professional excellence.

Transparency: Ensure clear, accurate and complete information in communications with stakeholders and take all decisions openly based on reliable information.

Quality of service: Provide state-of-the-art technical and managerial services within agreed time frame.

Striving towards excellence: Promote continual improvement as an integral part of our working and strive towards excellence in all our endeavours.

Quality Policy

We provide technical and managerial assistance to dam owners and State Dam Safety Organizations for proper surveillance, inspection, operation and maintenance of all dams and appurtenant works in India to ensure safe functioning of dams and protecting human life, property and the environment.

We develop and nurture competent manpower and equip ourselves with state of the art technical infrastructure to provide expert services to all stakeholders.

We continually improve our systems, processes and services to ensure satisfaction of our customers.

