2007-08

Field Training Report

Report submitted to-

Superintending Engineer,

Masonary Dam Circle, CDO, Nashik

(23/06/2008-29/06/2008)

अधिक्षक अभियंता,
दगडी धरण मंडळ, नाशिक

Superintending Engineer,
Masonry Dam Circle, CDO, Nashik

कार्यकारी अभियंता,
दगडी धरण विभाग क्र.४

Executive Engineer,
Masonry Dam Division-IV, CDO, Nashik

सरळ सेवा भरतीने नियुक्ती दिलेल्या सहाय्यक कार्यकारी अभियंता श्रेणी–१ अधिकाऱ्यांसाठी क्षेत्रीय प्रशिक्षण कार्यक्रम, जलसंपदा विभाग

Field Training for Direct Recruits - Assistant Executive Engineer (Grade 1) of Water Resource Department.

कालावधी: २३ ते २९ जुन २००८

Duration:23 to 29 June 2008

"क्षेत्रीय प्रशिक्षण अहवाल"

"FIELD TRAINING REPORT"

सादरकर्ता–

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(सहाय्यक कार्यकारी अभियंता)

Submitted by-

Pravin Kolhe, BE (Civil), MTech (IIT-Kanpur)

(Assistant Executive Engineer)

Executive Summary

Maharashtra Engineering Training Academy (META), Nashik organized training program for direct recruits - Assistant Executive Engineer & Assistant Engineer (Class I) of Water Resource Department (WRD), in accordance with Maharashtra Engineering Service Examination-2004. As per schedule of training program, we were directed to undergo training under the guidance of Superintending Engineer- **Shri. Rajendra Jaltare** saheb, Masonry Dam Circle, Central Design Organization, Nashik.

The training program was scheduled for one week and started on 23rd June 2008 and we were directed to study about Design of Masonry dam and its components under the guidance of Executive Engineer- **Shri. V.V. Sulakhe** saheb. We interacted with him and he guided us on subjects related to masonry dam such as General layout of dam, design of overflow and non-overflow section, design of energy dissipation arrangement and RCC pier, Guide wall and spray wall, design of drainage galley, design of barrage, grouting, and future challenges such as Foundation of dam on soft soil, and strengthening of masonry dam.

This report includes the day-to-day details of training program at Masonry Dam Division No-4, Masonry Dam Circle, Central Design Organization, Nashik. While writing this report, I had gone through various design standards like Design Process Manual, IS Codes, Central Design Organization, Nashik Standards, CWC Standards etc and I had given these references in the appropriate locations. The report also contains the study and observations performed by me. I learned valuable knowledge regarding Design Procedure of masonry dam through guidance by officers as well as reference material.

Acknowledgement

I take this opportunity to express my gratitude to those whose active help and support make this report possible in the present form.

First of all, I express my sincere gratitude to **Shri. Rajendra Jaltare, Superintending Engineer,** Masonry Dam Circle, Central Design Organization, Nashik for insisting in me the drive to work hard and for inculcating in me the discipline to think clearly.

It is the endless guidance and constant encouragement of Er. **V.V. Sulakhe** Saheb, Executive Engineer (Masonry Dam Division-IV) and I would like to express my heartfelt gratitude to him and his staff for providing me necessary technical information. He shared his valuable experiences with us and it was the most enjoyable part of training.

My special thanks to deputy engineer's- **Shri. L.G. Joshi,** and **Shri. S.S. Challawar** for their active help and valuable guidance. All the reports and reference materials were available for my study purpose.

Definitely the knowledge, I received during this training session was a lifetime experience and it will serve as a foundation for my career in Water Resources Department.

Last, but not least, I wish to express my gratitude towards my parents- Shivaji and Rohini, my grandparents- Rangnath and Sitabai, my uncle Raosaheb and aunty Radhika who sacrificed a lot to give me a good education.

- Pravin Kolhe BE (Civil), MTech (IITK)
(Assistant Executive Engineer)

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Chapter 1. About Central Design Organization, Nashik

1.1 Establishment of Central Design Organization, Nashik

Development programme to harness the available irrigation potential and also to increase the power resources were undertaken by the state of Maharashtra, India on a larger scale after independence by construction of dams and hydro power projects. To cope up with the need of providing designs of earth and gravity dams. Central Designs Organization (C.D.O) was established in 1957 by the Government of Maharashtra.

The CDO at that time had to start from scratch, but because of continuing efforts of the Engineers working in the CDO, the Organization is now recognized nationwide as a pioneer Design Organization in the field of Dam Design. Organization was strengthened for undertaking design of Hydro Electric Projects. It has now established its own design practices from the experience gained from the designs prepared and executed for last 51 years which has stood the test of the time and which are commensurate with the relevant BIS Code and USBR provisions.

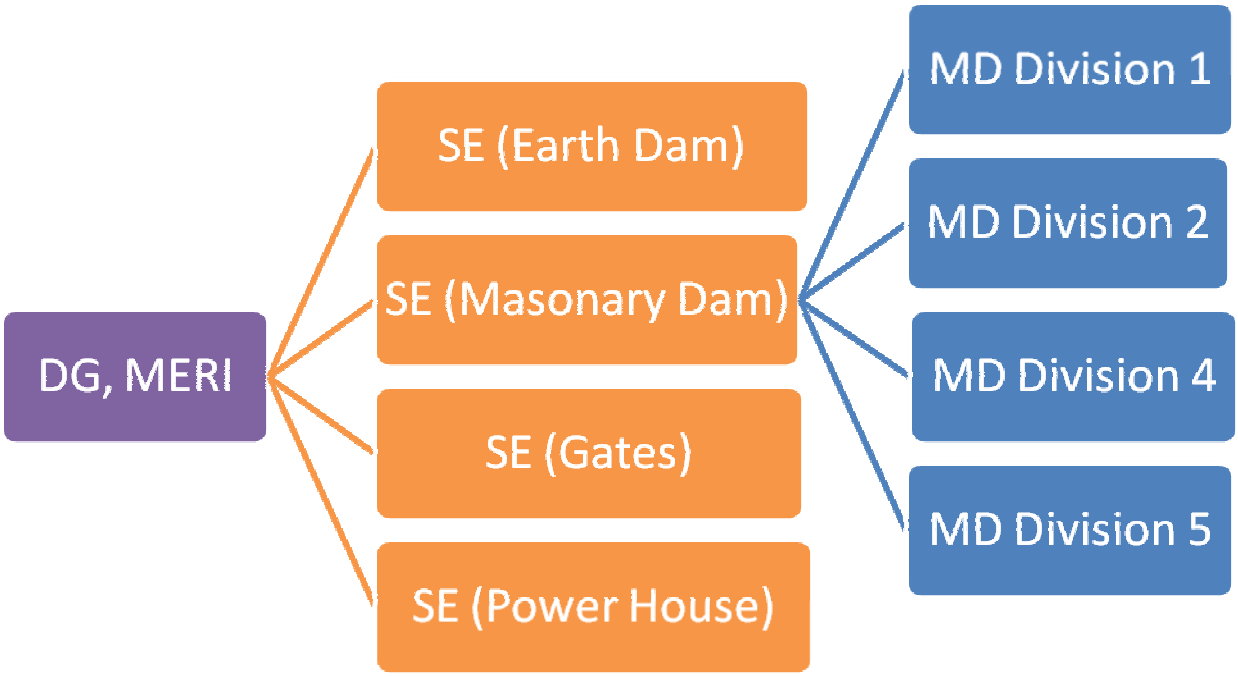
CDO is located at Nashik a central place connected with rail and road. It has its own building and residential quarters for the staff. The pioneer research institute of the state, Maharashtra Engineering Research Institute (MERI) is located in the same premises, which is complementary for the Design.

1.2 Activities of CDO

- Design of irrigation project /Design of Hydro Electric Project / Design of Lift Irrigation Scheme.
- Hydrology, Yield, Flood, Simulation studies and Flood routing.
- Detailed design of Earth dam, Gravity dam and its junctions.
- Design of different types of spillways / Energy dissipation arrangements.
- Instrumentation.
- Design of various types of Outlets.
- Design of all types of Gates.
- Design of various types of Major Canal Structures.
- Design of Hydro Electric Projects.
- Design of lift Irrigation Schemes.
- Review of old dams and suggesting remedial measures, if required.
- Scrutiny of Project Report for C.W.C. Clearance.
- Working on different Committees of BIS for preparation of various standards.
- Consultancy services for Semi Government / Private Sectors.

1.3 Organizational Structure

Maharashtra State is one of the developed states in India in agriculture sector. The policy makers have given due importance for the creation of irrigation potential for which construction of Major, Medium and Minor projects is taken up on a large scale. There are 1427 large completed dams in the state and many more are coming up. Central Designs Organization (CDO) is the state owned Organization under the Irrigation Department of the state entrusted with the activity of designing dams and other allied structures.

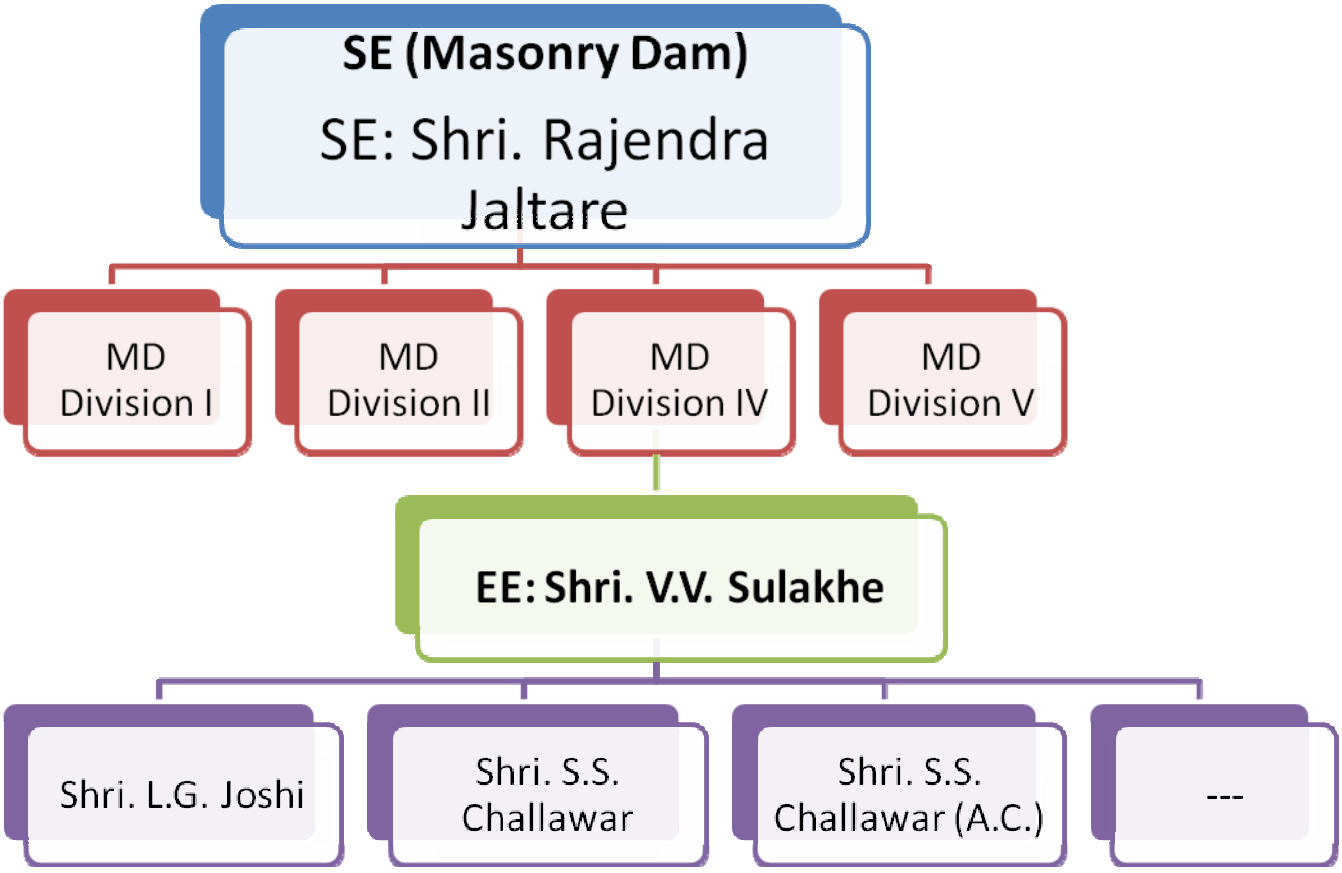


CDO was formed in the year 1957. It has four design circles headed by Superintending Engineer. Design units in each circle are headed by Executive Engineers which are assisted by Deputy Engineers and Assistant Engineers.

- All the staff is quite experienced and attained certain degree of expertise.
- All the key software's are indigenously developed to suit the needs of the design.
- Nearly 200 trained Engineers are working in this organization.
- It has its own building.
- The reputed Maharashtra Engineering Research Institute (MERI) is also located in the same premises. The model studies and other material testing work are carried out in the Institute which timely corroborates/supplements design needs.
- The organization has enormous amount of collection of various technical literature and fulfills needs of the time by adding on the latest.
- The organization has published number of papers in various1 national and international seminars.

Chapter 2 Masonry Dam Circle

2.1 Organizational Setup of Masonry Dam Circle



2.2 Role of Earth Dam Circle

Masonry Dam Circle mainly deals with the Design of Gravity Dams and Spillways. The activities involved are as below .

[1.] Preparing general layout of head works for Major Projects in Pune and North Maharashtra Region.
[2.] Preparing layout of Gravity Dam /Spillway.
[3.] Deciding type and appropriate location of spillway-gated/ungated
[4.] Deciding control levels- flood routing
[5.] Deciding most economical Non-Overflow and Overflow section and checking its stability for various conditions as per the relevant standards.
[6.] Deciding suitable Energy Dissipation Arrangement (EDA) to pass the flood safely and deciding the necessity of model studies.

[7.] Detailed design of all components of Gravity Dam and EDA
   a. Gallery and adits
   b. Lift well and stair case
   c. Crest
   d. Glacie
   e. Drainage arrangement
   f. Piers and Bridge
   g. Spray wall
   h. Guide wall
   i. Tail channel and protective arrangement

[8.] Design of junction between Earthen Dam and Gravity Dam.

[9.] Provision of various types of instruments.

[10.] Review of Old Gravity Dam and suggesting strengthening measures like buttressing and full backing/ cable strengthening.

[11.] Suggesting remedial measures for the various problems faced by the Gravity Dams seepage etc.

[12.] Checking of the project report to be submitted to Central Water Commission for clearance of Amravati region and North Maharashtra region.

[13.] Deciding the suitability of foundation of dam , mapping of foundation and preparing geological reports from the Subsurface investigations ,through geological unit headed by the Senior Geologist.

[14.] Providing consultancy services to Semi Government and Private Organisations.

[15.] Working of various committees of Beauro of Indian Standards (BIS) for updating the standards.

All the data required for the design needs to be supplied by the field, offices.

2.3 Major achievement of Masonry Dam Circle

- Successfully carried out design of 85 m. high Masonry Dam.
- Introduced colgrout masonry construction for Gravity Dam.
- Provided designs for strengthening of 12 old Gravity Dams.
- Morning Glory Type spillway for Kasarde project near Kolhapur.
- Side Channel spillway for Chapdoh project near Yeotmal.
- Design of Lift irrigation Schemes .
- Standardisation of K.T. Weir of different road (slab) width.
- Design of K.T. Weir in permeable strata with concrete diaphragm.
- Design of K.T. Weir with raft on impermeable soil strata.
- Design of Labyrinth type weir.
- Design of Barrages on Tapi river.

2.3 Masonry Dam Circle is Consultant to-

Maharashtra Industrial Development Corporation,
Maharashtra State Electricity Board,
Maharashtra Jeewan Pradhikaran.
Mumbai Municipal Corporation,
Nashik Municipal Corporation,
M/s Tata Power Company,
Sahara India Housing Corporation Ltd., Mumbai.
M/s Nippon Denro Co. Ltd.,
Bombay Sub-urban Electricity Board.

2.4 Field Data For Gravity Dams

1) Administratively approved Project Report
2) Copy of approved / proposed general layout
3) Gross storage
4) Live storage
5) Dead storage
6) Dependability
7) Control levels
8) Flood.
9) Other salient features.

Details of spillway.	**Pier resting on foundation or overflow.**
Gated/un-gated	End Pier resting on OF/ NOF/ Divide wall.
If gated, no. & size of gates.	Design inflow flood
Length of spillway.	Corresponding outflow
No. of piers	Type of junction.
Width of pier.	Type of EDA.

10) Block contour plan showing the proposed dam alignment and project layout covering an area 300 m. upstream and downstream of approved alignment.
11) Dam site studies.
12) Geological Report including bore hole data with logging including water-in-take at various depths.
    a. Bores on L-section of dam.
    b. Bore holes for spillway, approach and tail channel.
    c. Bore holes at outlet location.
13) Soil properties for proposed earth dam. Borrow area plan showing quantities of embankment material available.
14) Hydraulic Data-
    a. L-Section and contour plan of tail channel (with rock contours) showing bed slopes.
    b. Tail water curve for various discharges.

c. Area capacity curve drawn by area reduction method. Area and the capacity on the basin for about 2m above the probable M.W.L.
d. Upstream constraints for fixation of M.W.L. and downstream constraints for flood releases.
e. River carrying capacity.

15) Information about provision of construction and river sluices.

2.5 Major Projects Designed by Masonry Dam Circle

1. Arunawati	**2. Bagh**	**3. Bhawanthadi**	**4. Bembla**
5. Bhama Askhed	6. Bhandardara	7. Bhatsa	8. Bhima
9. Bhima Sina (Joint Canal)	10.Chaskaman	11. Dhombalkwadi	12. Dudhganga
13.Ghod	14. Girna	15. Godavari (Dharna)	16. Gosikhurd
17. Gunjawani	18. Human	19. Itiadoh	20. Jayakwadi
21. Jayakwadi (II)	22. Jigaon	23. Kadava (Karanjawan)	24. Kadwa
25. Kai	26. Kalisarar	27. Khadakpurna	28. Khadakwasla
29. Khodshi gated weir	30. Krishna	31. Krishna Canal (Extension)	32. Kukdi
33. Lendi	34. Lower penganga	35. Lower Dudhana	36. Lower Tapi
37. Lower Terna	38. Lower Wardha	39. Lower Wunna	40. Manjra
41. Mula	42. Nandur Madhameshwar	43. Neera Deoghar	44. Neera L.B.C.
45. Pench	46. Punad	47.Purna (Siddeshwar/yeldari)	48. Pus
49. Sangola Branch Canal	50. Sina Kolegaon	51. Surya	52. Talamba
53. Tarali	54.Temghar	55. Tillari	56.Tulshi
57. Tultuli	58. Upper Penganga	59. Upper Wardha	60. Upper Godawari
61. Upper Prawara	62. Upper Tapi st-I	63. Urmodi	64. Veer
65. Vishnupuri	66. Waghur	67. Wan	68. Warangaon Talvel
69. Warna			

2.5 Lift irrigation Schemes Designed by Masonry Dam Circle

1. Barshi	**2.Bhagpur**	**3. Bodwad**	**4. Dahigaon**
5. Ekrukh	6. Janai Shirasai	7.Jilhekathapur	8.Krishna Koyana
9.Kurha Wadoda	10.Purandhar	11.Shirapur	12.Sina Madha
13. Tembhu			

Chapter 3 General Layout of Masonry Dam

3.1 General Layout of dam

The deputy engineer in charge of work will be responsible for preparing the layout based on the field data and to prepare data sheet approved from Executive Engineer. Executive Engineer will verify the field data with its source. Assumptions to be made in absence of data shall be approved from Superintending Engineer, who will submit the same to competent authority for approval.

3.1.1 Procedure to be followed-

1. Preparation of data sheet and approval of Executive Engineer.
2. Location of spillway based on bore data, suitability of EDA[1], tail channel layout, economical studies and approach to the spillway.
3. Type of dam based on economy and resources.
4. Siltation Studies as per CBIP[2] Technical Report No. 19.
5. Flood Studies as per IS: 11223-1985.
6. Type of spillway: Gated/Un-gated.
7. Free Board as per IS:6512-1984 and IS:10635-1993.
8. Control Levels such as MDDL, Sill Level/Power Outlet Level, FRL, MWL, TBL.

3.1.2 Layout of Gravity (Masonry) dam

Following are important components while deciding the layout of masonry dam-

1. Non-Overflow Section/Overflow Section (IS:10135-1985)
2. Monolith Arrangement (IS:11155-1994)
3. Pier (IS:13551-1992)
4. Type of EDA (IS:10137-1982)
    a. Horizontal Stilling Basin
    b. Roller Bucket (Slotted/Solid)
    c. Flip Bucket
5. Guide Wall and Spray Wall (IS:12720-1989)
6. Grouting
    a. Consolidation Grouting
    b. Curtain Grouting
7. Gallery (IS:10135-1985)
8. Junction

[1] Energy Dissipation Arrangement
[2] Central Board for Irrigation and Power

9. Contraction Joints (IS:12200-1987)
10. Instrumentation (IS:7436-1976)
11. Bridge
12. Construction Sluice
13. Earth Dam (Designed by Earth Dam Circle of CDO, Nashik)
14. Head Regulator

3.2 Design of Overflow Section

Essential Field data for design of OF[1] section-

1. Finalization of design flood
2. Geological report and foundation level
3. Finalization of construction material
4. Finalization of Control levels
5. Fetch Calculations and Free Board
6. Other data like, river bed slope, contour map, flood ordinates etc.

OF sections are provided in the spillway portion of masonry/concrete dam. There are following two types of OF sections commonly adopted in Maharashtra-

I. Ogee Type (IS: 6934-1973)
II. Narrow/Broad Crest Weir.

3.2.1 Design of Ogee Type Spillway

1.	**Hydraulic Design**	**IS:6934-1973**
2	Profile of Ogee Type OF Section	USBR-Design of Small Dams, Chapter IX
3	Structural Design	
3.1	Dead Load	IS:6512-1984- "Criteria for Design of Solid Gravity Dams"
3.2	Reservior and tail water load	
3.3	Uplift Pressure	
3.4	Earthquake Forces	
3.5	Earth and Silt Pressure	
3.6	Ice Pressure	
3.7	Wind Pressure	
3.8	Wave Pressure	
3.9	Thermal Loads	
4	Load Combinations for Design Purpose	IS:6512-1984
5	Stability Analysis	
6	Check for Sliding and Overturning	IS:6512-1984
7	Foundation	IS:11155-1995
8	Foundation Treatment	CDO/MD/GRT-1988
9	Crest for Ogee Section	IS:11155-1995

[1]Over Flow

10	Construction Material	Circular:09.07.2002
11	Glacis Concrete	IS:11155-1995
12	Provision of Drainage Gallery	IS:10135-1985
13	Fillet Provision	Concrete Dam by R.S. Varshney
14	Foundation Anchors for Protection against vibration	
15	Width of Full on upstream	
16	Approach Conditions	
17	Cold Joint	
18	Contraction Joints and Monoliths	IS:12200-2000 and IS:11155-1995
19	Instrumentation	

3.3 Design of Non-Overflow Section

Selection of NOF depends upon the site condition. Normally an irrigation or hydropower project envisages construction of composite dam. Major part of dam consist of earthen embankment and masonry/concrete masonry /concrete part mainly consist of two components as under-

1. OF section to pass the design flood
2. NOF/Divide Wall and Wing Wall to retain the adjoining earthen embankment.

As per Government of Maharashtra Marathi circular dt. 09.07.2002, construction of UCR masonry for dam is totally banned. Hence NOF portion as per further directives in circular, colgrout masonry can be constructed if best quality natural sand is available and quantum of work is comparatively small. This implies that either complete dam is to be constructed with u/s septum in M15 CC[1] with backing portion in colgrout masonry or concrete of grade not less than M10 CC.

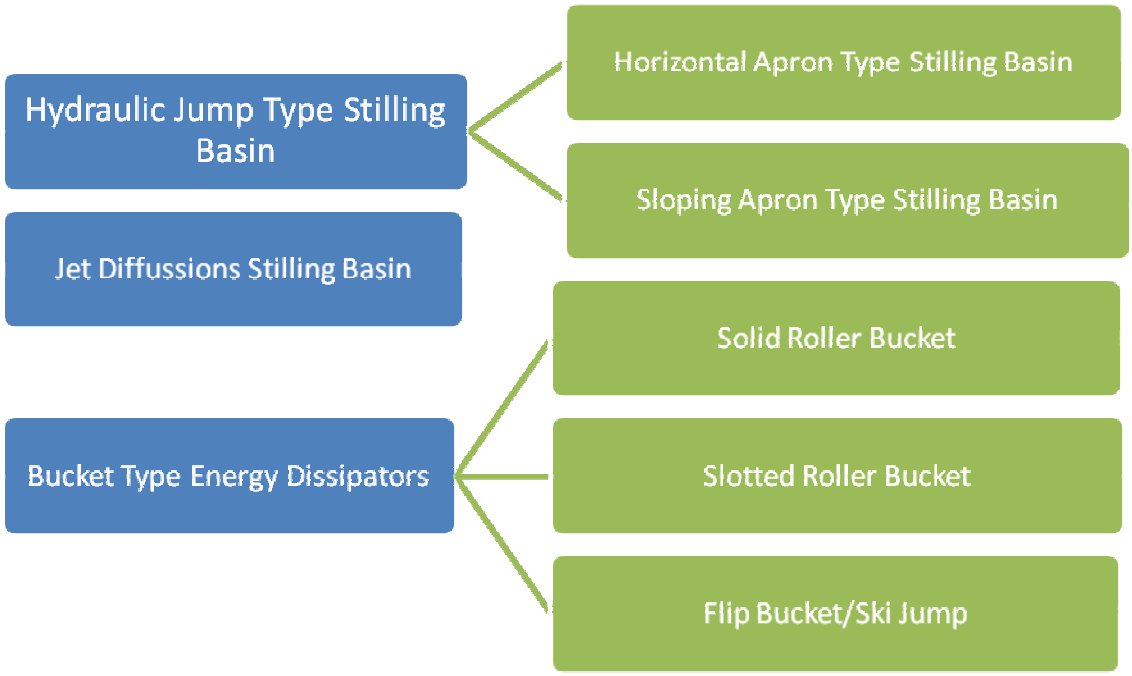
3.4 Energy Dissipation Arrangement

Following field data is required-

1. Tail Water Rating Curve
2. Bore Hole Data
3. Geological Report
4. Block Contour Plan at the location of EDA
5. Downstream river carrying capacity of parent channel, if spillway is located in gorge.
6. Block contour plan showing alignment of Tail Channel upto confluence.
7. L-Section of tail channel up to confluence showing GL.

[1] Cement Concrete

3.4.1 Type of EDA



3.4.2 Factors Affecting Selection of Type of EDA

1. Frequency and Intensity of Design Flood.
2. The degree of protection (to be provided for very high floods)
3. Type of dam and its spillway
4. Proximity of Power house tailrace and other structures
5. Nature of foundation
6. Velocity and nature of flow.
7. Elevation of tail water at various discharges.
8. Safety of existing structures on downstream.
9. Any special consideration such as deep pool of water in close proximity of dam on its downstream.

3.5 Drainage Gallery and Sump Well

The necessity of foundation and inspection gallery will be decided based on the following criteria-

1. Foundation gallery shall be provided in the body of dam where height of water column (FRL) above normal foundation level is more than 20m. (measured up to crest level in the case of un-gated spillway)
2. For water head more than 40m up to 60 m inspection gallery shall be provided.

3. For every 20 m increase in the head beyond 60 m additional inspection gallery shall be provided.

3.5.1 Layout of Drainage Gallery

Following provisions shall be made as per IS: 12966-Part II-1990 and present CDO code of practice-

1. **Size : 1.5 x 2.3 m Thickness : 0.75 m**
2. **Floor level: 1.5 to 2 m above the Foundation RL**
3. **Trade of step = 250 mm and rise = 200 mm, if slope of the foundation is steeper than 17. Landing shall be provided for every 5 m rise in the formation level. Provision of MS angles of 25 mm shall be made as noses to the steps to avoid damage during hauling of machinery.**
4. **Gutter : 300 x 300 mm on upstream side of floor of gallery.**
5. **Location: Minimum distance from upstream face of dam to upstream inner face of gallery shall be 5% of water head or 3 m (minimum)**
6. **Provision of lift, if height exceeds 40 m.**
7. **PVC water stop as per IS:12200-2000**

3.6 Sump Well

Capacity of sump well shall be worked out on the basis of seepage collected in the gallery in 30 minutes at the rate of 0.3 Cum/100 m length /meter average head and efforts shall be made to drain out gallery by gravity.

Gallery shall be designed as per IS:10135-1985 and as per IS:12966 (Part II)-1990.

3.7 Adits

1. Adits shall be provided for access to the gallery from downstream side.
2. Size: 1.5 x 2.3 m
3. Design criteria is similar to that of Galleries
4. Easy access to the inspection gallery and foundation gallery shall be ensured
5. For dams having more than one gallery, provision of staircase cum lift well shall be in invariably made at suitable locations.
6. In case of 'V' shaped gorges, where layout of adit requires cutting provision of staircase/shaft shall be made.

3.8 Spillway Pier

The design of spillway pier shal be undertaken after receiving radial gate general layout prepared by Gates Circle of Central Design Organization, Nashik. Spillway pier shall be desiged in accordance with IS:6512-1984, IS:13551-1992, IS:SP 55-1993, IS 456-2000. M20 CC grade is recommended to Government and shall be adopted after Government approval.

3.9 Divide Walls/ Guide Walls/ Spray walls

3.9.1 Divide Walls

Divide walls are provided for separating spillway from earth dam. This wall is parallel to earth dam profile so that earth work will not enter in to flow of Spillway and approach channel. The wall shall rest on sound foundation rock. This is important part of dam so important factor is to be taken as per that of Overflow and Non-overflow.

3.9.2 Guide Walls

Guide walls are provided on sides of EDA. Similarly guide walls are provided to guide the flows in approach and tail channels and protect the banks if necessary. The walls shall rest on sound foundation rock. Importance factor should be taken as One.

3.9.3 Spray walls

Spray walls are provided to obstruct the outflanking of outflow of spillway. Spray walls are resting on overflow or adjacent non-overflow and guide walls and at the top they are obutted to end piers.

3.10 Instrumentation

From considerations of usefulness of data obtainable, importance of data and cost aspects the measurement required can be grouped in two categories.

1) Obligatory measurements :-
2) Optional Measurements

1) Obligatory Measurements

Following Types of measurements are required to be done as Obligatory in case of masonry/concrete dams.

a. Uplift pressure measurement, arrangement to give information regarding uplift.
b. Seepage measurements on D/s. and in galleries.
c. Temperature of the interior of the dam as determined by thermometers
d. Displacement measurement.

2) Optional measurements :-

Certain optional measurements would be warranted for high dams and for dams with a special considerations in respect of unusual design, difficult & doubtful foundations for monitoring and verification of design criteria.

a. Rock and foundation deformation.
b. Tilt.
c. Stress
d. Strain
e. Pore pressure
f. Seismicity

Instruments are classified in to mechanical, hydraulic, Pneumatic, Electrical/ Electronic (resistance type & vibrating wire type) Optical and Fibre Optic sensors type based on working principle. Separate or combination of these are also used when required.

3.11 Foundation Grouting

Very often seams and faults or band of shattered rock extending to large depths may be encountered during drilling or excavation of foundation. Such weak material will not take appreciated load and the structure will have transfer the load to the firm rock on the two sides of the weak zone by spanning over it, thus leading to stress concentrations both in the foundation rock and the structure. Sine it is not practicable to remove the weak material to its fall depth. The technique used to consolidate the foundation rock is pressure grouting.

Pressure grouting technique is the process of injecting suitable cementituous slurries or similar material into inaccessible places for the purpose of seams, cracks and fissures or filling voids. While the principal used of this process is to fill openings in a structural mass and render it impervious to percolating water. It is also used to improve the strength and elastic properties of the material into which it is injected. The principal purpose of foundation grouting is to establish an effective barrier against flow of water. Thereby preventing leakage and reducing the hydrostatic uplift pressure under the structure. Another purpose is to fill the voids in the near surface rock under the structure and thus secure more uniform and monolithic foundation.

Chapter 4. Design of Barrage Layout and Strengthening of Dam

4.1 Introduction

It is a barrier provided with a series of gates over its entire length across the river to store water & regulate the water level and pattern of flow upstream. Location for a barrage shall be decided on the consideration of its suitability for the purpose it has to serve. e.g. for irrigation purpose. The head works shall be planned in such away that full command may be obtained by a barrage of reasonable height.

At the location of barrage, the river reach should be straight as far as possible so that velocities shall be uniform and the sectional area of upstream of barrage is fairley constant. The banks should be preferably high, well defined and inerrodable. The alignment of a barrage should be such as to ensure normal and uniform flow through all barrage bays as far as possible. Therefore perpendicular alignment is preferable to skew alignment.

4.2 Field Data

For study of field data, the following points shall be observed which are essentially required for the design of barrage.

1. Contour plan at the location of Barrage, showing details viz. Command, roads etc.
2. Geological Report based on bore data (with water intake test results & core recovery) on barrage alignment and upstream & downstream of barrage as specified for that particular barrage site.
3. Detail survey showing c/s of the river upstream & downstream of the barrage & 'L' section of river for a distance as specified for that particular barrage site.
4. Submergence Plan at F.R.L. & M.W.L.
5. Design flood (Inflow Hydrograph).
6. Availability of construction material.
7. General Layout of Barrage approved by competent field authority with due cognizance of above referred points.

4.3 Design Procedure

Barrage structure proper essentially has following components.

1. Spillway portion with vetical lift gates with sill necessarily at average river bed level.
2. Divide wall or N.O.F. on either side of spillway as per site situation.
3. Pier & Bridge .
4. E.D.A. arrangement to pass spilled over water by dissipating energy to the downstream river portion.

Components of barrage :-

1. Spillway.
2. Divide wall
3. Key Wall
4. Non overflow section
5. Pier
6. Bridge
7.

4.4 Loading Considerations

Various wheel loads and dimensions as per IRC code of practice for Road Bridges - section II are to be considered as under-

i) Class AA
ii) Class B
iii) Service Gate crane loading
iv) Goliath crane loading.

4.5 Necessity of Strengthening of Dam

The different conditions in which the strengthening of dams is required are as below.

4.5.1 Design Concepts

Many of the old dams ware designed without considering uplift force and / or earthquake force. In some cases the earthquake forces considered are inadequate. These dams with present design norms, are found to be unsafe. Such dams though they may not have shown signs of any distress, will have to be strengthened so as to increase their serviceable life, and to avoid any sudden danger of failure, causing loss of life and property. While raising of the dam to increase storage capacity, the existing dam needs to be strengthened.

4.5.2 Signs of Distress

Due to inadequate design assumptions or failure to achieve the stipulated strength or loss of strength due to aging or due to some unknown geological and / or other factors like increased seismic activities a dam may show sudden or progressive signs of distress indicated by increase in leakages, excessive

deflections, spouts of jets from downstream face and visible cracks etc. In such cases, emergency measures and then permanent strengthening measures are required to be taken.

4.5.3 Raising of Dams

Some dams become unserviceable due to silting or in some cases the capacity has to be increased. To restore the original capacity of reservoir or to increase the capacity, some times it is economical and feasible to raise the old dam. While raising, the dam may need strengthening.

4.6 Investigation

When it is decided that the dam need strengthening, the following investigations are required to be carried out to decide the method of strengthening.

1. Density of old dam is required to be ascertained as it is very important parameter in the design of gravity dam. Care should be taken that the density taken should be worst as this portion of dam would be vulnerable.
2. The compressive and tensile strength of the dam shall be decided by testing the sample cores. In case it is not possible to take out cores, then Non-destructive test by measuring wave-velocity may be carried out. Based on these strength values, the methods and criteria for strengthening can be fixed.
3. In case of distress such as cracking or excessive leakages, the detailed investigations such as the extent of cracking, the source of leakage etc. needs to be made very carefully to decide upon further treatment. Depending upon the signs of distress and the stress picture in pseudostatic analysis if it is found necessary, dynamic analysis is to be carried out.
4. The instrumentation data if available also shall be studied.
5. Any other relevant investigations depending upon the situation shall be carried out, particulars for deciding earthquake parameters, if the area is seismically active, etc.

4.7 Methods of Strengthening

I. Post-tensioning cables.
II. Earth backing.
III. Providing drainage gallery.
IV. Masonry or concrete backing.

Chapter 6. Conclusion

The training session at Masonry Dam Division-4 of Masonry Dam Circle, Central Design Organization, Nashik, was the most enjoyable session for me. I joined Masonry Dam Division-4 on 23rd June 2008 under the guidance of Executive Engineer - **Shri. V.V. Sulakhe** saheb and interacted with him along with the staff of division. Training session ended on 29th June 2008 and this report includes the summary of the training.

I learned the procedure of Design of Masonry Dam, Design of barrage and its components and strengthening of dam.

It was nice experience for me since I could realize the importance of Masonry Dam Design Division.

At last, I am thankful to Superintending Engineer- **Shri. Rajendra Jaltare,** Saheb, Executive Engineer- **Shri. V.V. Sulakhe** saheb, and Sub-Divisional Engineer **Shri. L.G. Joshi & Shri. S.S. Challawar** and all the staff of division for providing me an opportunity to enjoy the thrill of design and providing all the necessary documents and related procedure.

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