# ထူးကဲရေကြီးမှုဒဏ်ခံမင်းမြင်ရေလှောင်တမံ၏ဖြစ်စဉ်ကိုလေ့လာခြင်း

### A Case Study on the Extreme Flood Affected Minmyin Dam

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ဗဟိုကော်မတီဝင်၊ တတိယအကြိမ် မြန်မာနိုင်ငံအင်ဂျင်နီယာကောင်စီ (MEnggC)

တွဲဖက်အထွေထွေအတွင်းရေးမှူး၊ မြန်မာနိုင်ငံတမံကြီးများ ဆိုင်ရာ အမျိုးသားအဆင့်ကော်မတီ (MNCOLD) အကြံပေးအဖွဲ့ဝင်၊ အမျိုးသားအဆင့်ရေအရင်းအမြစ်ကော်မတီ (NWRC) အကြံပေးအဖွဲ့ဝင်၊ အမျိုးသားအဆင့်သဘာဝဘေးစီမံခန့်ခွဲရေးကော်မတီ (NDMC)

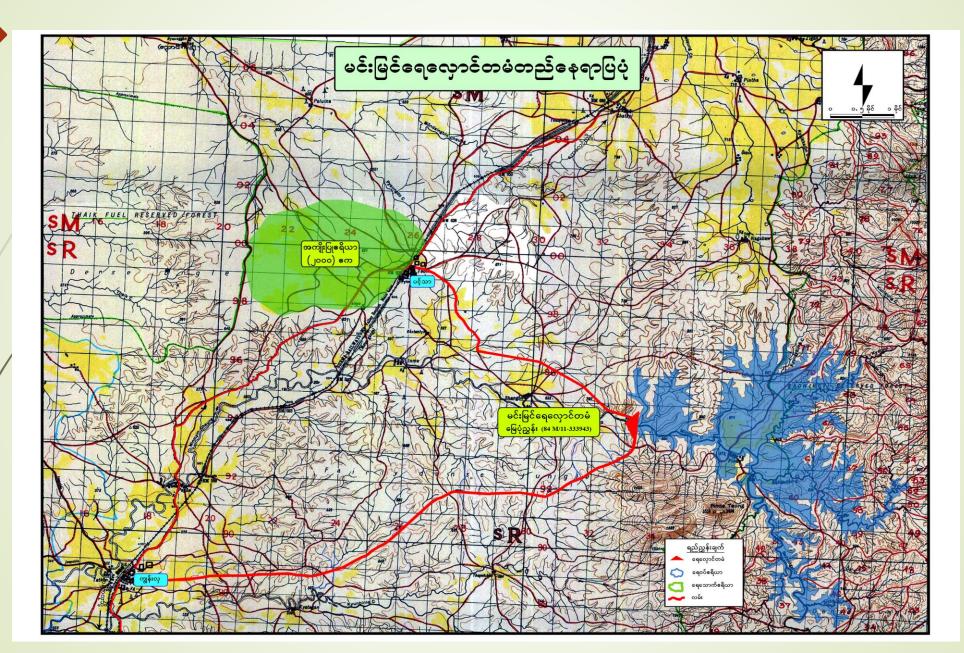
ဦးဗစ်တာ ညွှန်ကြားရေးမှူး(ငြိမ်း) ဆည်မြောင်းဦးစီးဌာန

# ၂၀၁၅ ခုနှစ် ဇူလိုင်လ ၁၈ ရက်နေ့က ထူးကဲရေကြီးမှုကြောင့် မင်းမြင်ရေလှောင်တမံအပေါ်မှ ရေကျော်ခဲ့သော်လည်း တမံကျိုးပေါက်မှု မဖြစ်ခဲ့ပါ။

Due to an Extreme Flood, Dam Overtopping Happened on

18 July 2015 but Minmyin Dam was Safe.

#### **Project Layout**

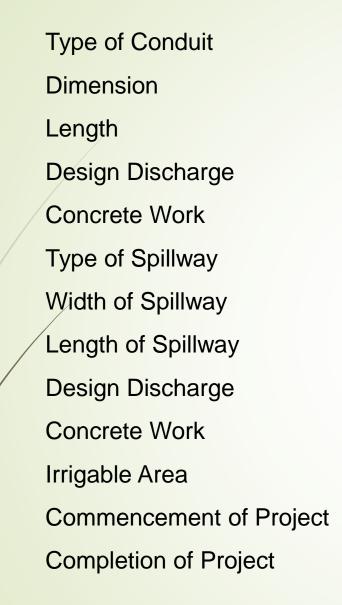


### Salient Features of the Minmyin Dam Project

River Catchment Area Average Annual Rainfall Average Annual Inflow Dam Type Dam Height Dam Length Full Tank Capacity **Dead Storage Capacity** Water Spread Area Earthwork Excavation Earthwork Filling

Location

- Shan Kon village, Kantbalu Township,
   Sagaing Division
- Minmyin, Tributary of the Mu River
- 64 sq. mi
- 42 inches
- 14620 ac ft.
- Earthen dam
- 88 ft.
- 2350 ft.
- 19010 ac ft.
- 3740 ac ft.
- 1085 ac
- 119900 sud.
- 261380 sud.



- R.C.C Rectangular Box
- 4 ft. x 6 ft.
- 203 ft.
- 60 cusec
- 349 sud.
- Broad Crested
- 80 ft.
- 1240 ft.
- 8731 cusec
- 2372 sud.
- 2000 ac
- 2010 2011
- 2015 2016

## **Geological Investigation in Foundation**

Drill Holes along the dam axis, conduit and spillway for recording boring log of

- Subsurface soil classification, confirming groundwater table and bed rock
- Bearing Capacity by Standard Penetration Test (SPT)
- Permeability by Water Pressure Test (Lugeon Test)

**Standard Penetration Test** — to count no. of Blows N/ft. (N – Penetration resistance)

Mass of hammer 140 lb., drop height 2.5 ft. at the rate of 30 blows per min

Acceptable Bearing Capacity - Blow counts N > 20/ft., the best N > 50/ft.

Water Pressure Test – to find Lugeon value,

1 lugeon = 1 L/m/bar at a test pressure of 10 bars =  $1.3 \times 10^{-5}$  cm/s

Acceptable Permeability – Lugeon value < 10 lugeon

#### **Conclusions of Geological Investigation**

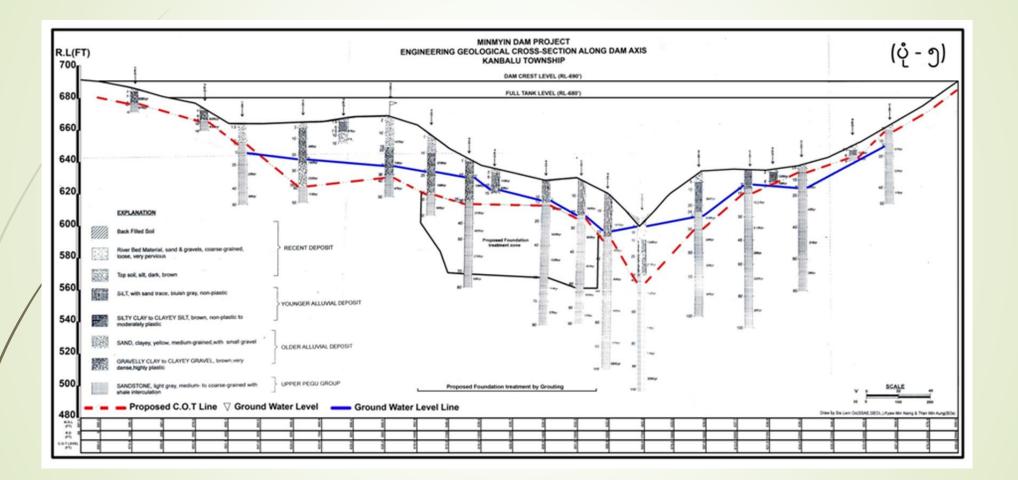
**Bearing capacity** by SPT at Chaung section, blow counts N = 4 no./ft.

To remove soft soil up to 20 ft. depth below Chaung bed.

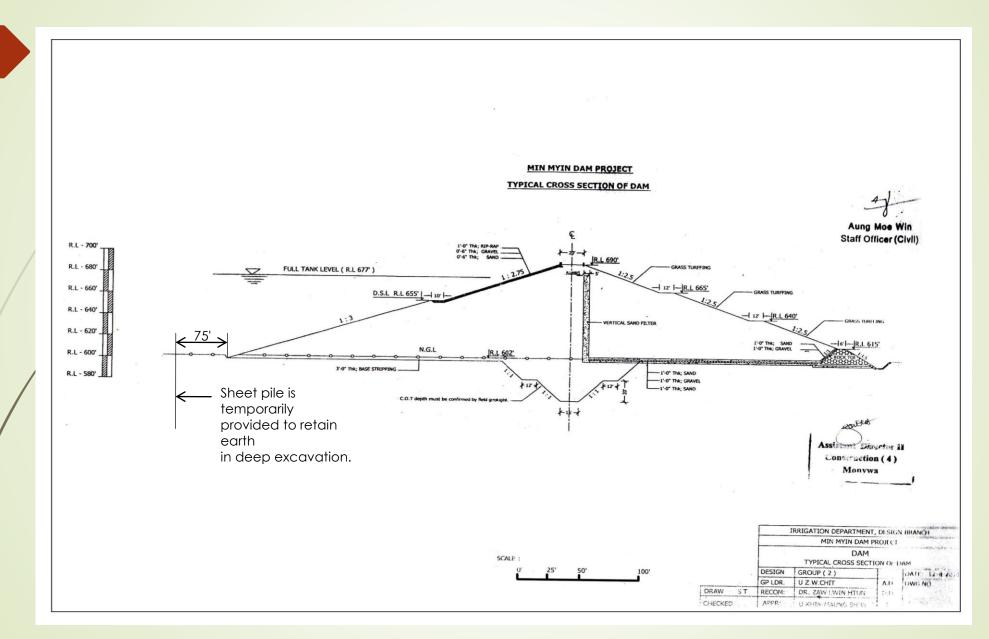
**Permeability** by Lugeon Test at right bank > 10 lugeons

To conduct **Cement Grouting** at the right bank.

#### Longitudinal Dam Axis



#### **Cross Section of Dam**



# **Terminology for Dam**

Freeboard – height between full tank level and dam crest (ရေလွတ်အမြင့်)

**Riprap** – random stone dumping on the upstream slope of dam on filter layers (sand

and gravel both meet filter criteria) to resist wave actions. (လှိုင်းကာကျောက်)

Grass Turfing – protection of downstream dam slope from rains by grass. (မိုးရေခံမြက်) Cut-off – to cut seepage through dam foundation and to resist sliding (သပ်ကျင်း) Vertical Filter – sand filter in vertical position within the dam. (ဒေါင်လိုက်ရေစစ်သဲ) Horizontal Filter – sandwich of sand and gravel filter in horizontal position at the base

of dam in connection with vertical filter. (ပြင်ညီရေစစ်သဲ)

Rock Toe – random rock dumping at downstream dam toe for releasing seepage properly from horizontal filter and for stability of dam. (ရေစစ်ကျောက်ရိုး)

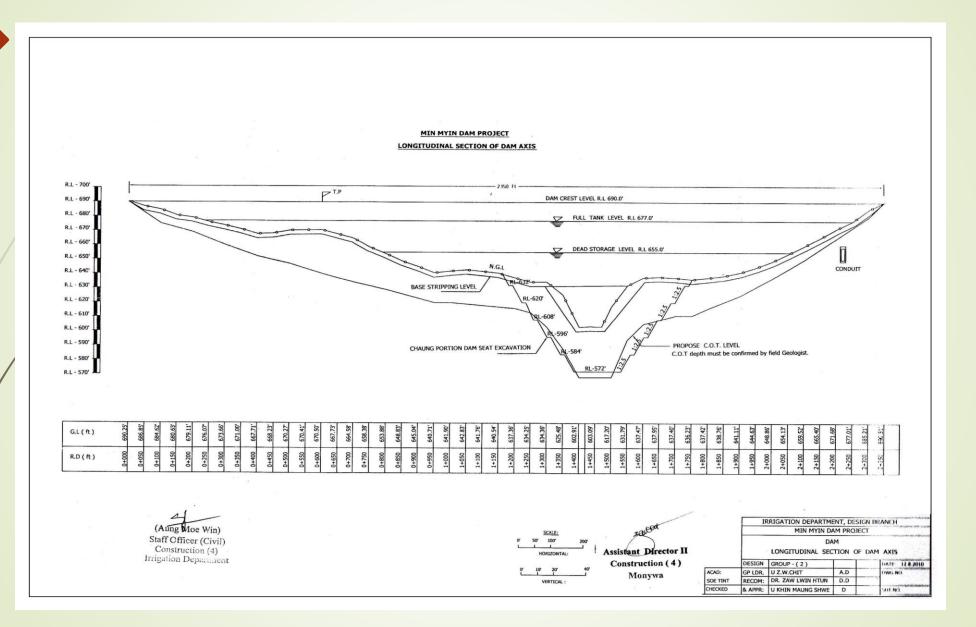
#### The Reasons of Removing Soft Soil in Chaung Section

- To improve Bearing Capacity
- To avoid arching and uneven settlement at the Chaung section

Arching (ထမ်းထားခြင်း) ကျဉ်းမြောင်းသော Dam Section တွင် တမံမြေဖို့ပါက ဘေးနံရံ နှစ်ဖက်က ထမ်းထားခြင်းကြောင့် အောက်ခြေတွင်ဟသွားကာ Piping Failure ဖြစ်နိုင်ခြင်း၊

Uneven Settlement (ဘက်မညီသောနိမ့်ဆင်းမှု) ချောင်းပိုင်းရှိတမံ၏နိမ့်ဆင်းမှုကြောင့် တောင်စောင်းပေါ် ရှိတမံတို့အကြား ဟသွားကာ Piping Failure ဖြစ်နိုင်ခြင်း၊

#### **Removal of Soft Soil in Chaung Section**





RD- (1300) မှ RD- (1500) အတွင်း ချောင်းပိုင်းမြေကြီးလုပ်ငန်း ဆောင်ရွက်နေပုံ

Foundation Excavation & Filling



Steel Sheet Pile ရိုက်ခြင်းလုပ်ငန်းဆောင်ရွက်နေပုံ

#### **Driving Sheet Pile**

### The Purpose of Sheet pile

- To retain earth for excavation in Chaung section
- for curtailment of seepage from upstream of Chaung

A single sheet pile line was driven 75 ft. from upstream toe of dam.

After completing dam filling in Chaung section, it was removed.

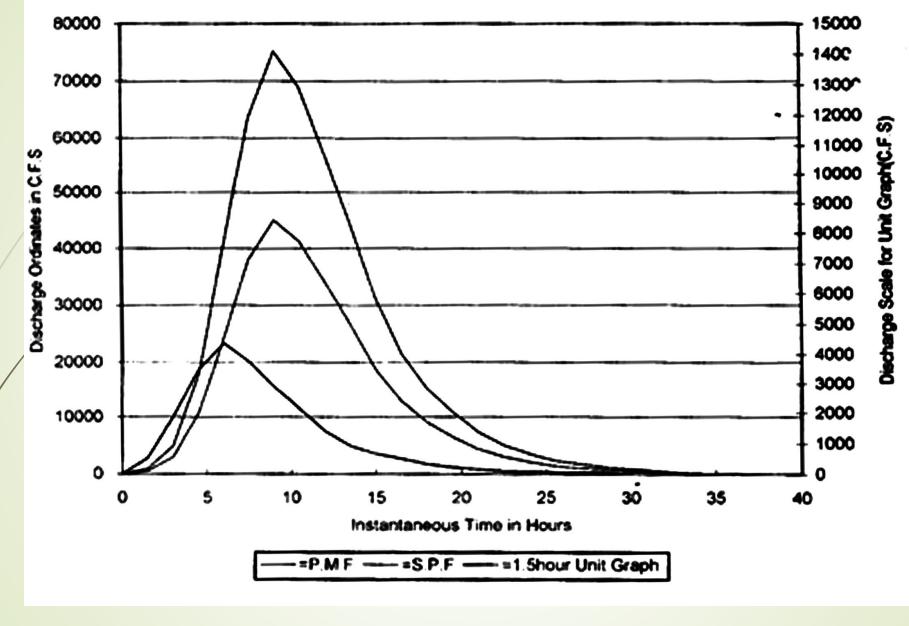


Completed Dam

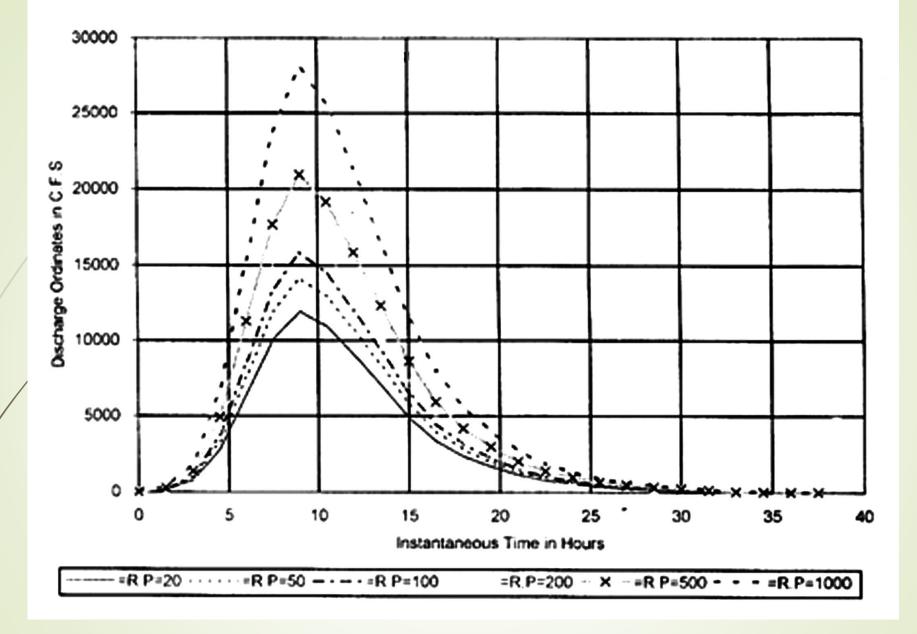
Completed Spillway

### **Design Routed Floods**

	Return Period	Rainfall	Pe	ak Discharge	Routed Discharge
	1000-yr	11″	280	092 cusec	8731 cusec
	10000-yr	17″	45	036 cusec	14696 cusec
	PMF	29″	75	212 cusec	
	-				
/	10000-yr routed flood R.L 10000-yr flood volume 1000-yr routed flood R.L		=	692.727 ft.	
			=	35245 ac ft.	
			=	687.980 ft.	
	1000-yr flood volume		=	21960 ac ft.	



10,000-yr, PMF

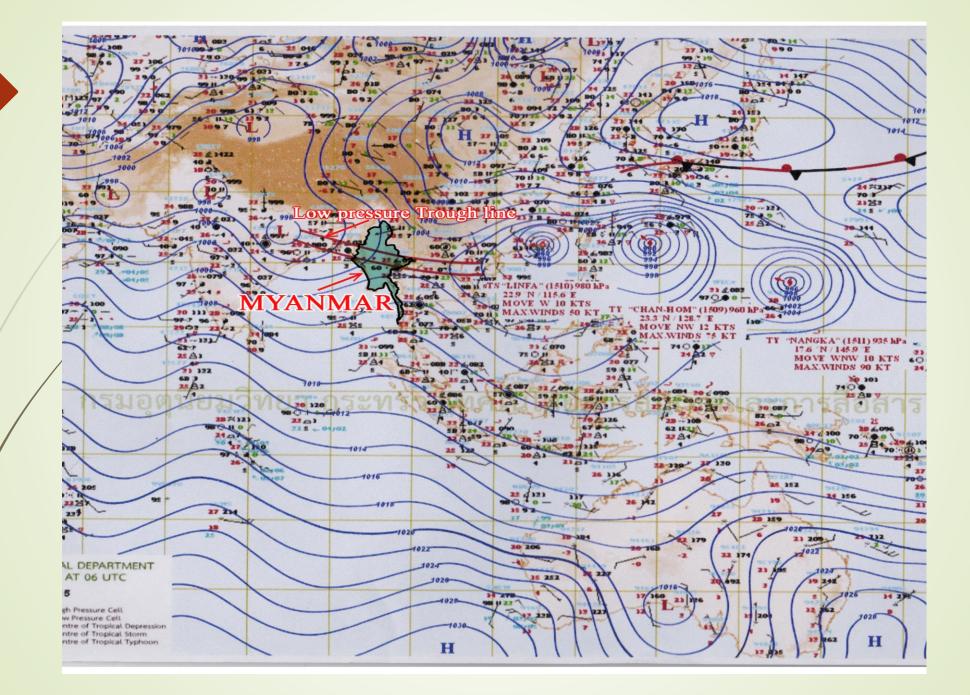


1,000-yr

## The Main Cause of Flood

The meteorological phenomenon called Low Pressure Trough line started to form over Myanmar in connection with low pressure cells from India and a series of **Typhoons** from South China Sea, the Pacific Ocean on July 5, 2015. A series of typhoons called Linfa, Chanhom, Nanka and finally Halola happening simultaneously not one after another after time lapsed or landfall.

This incident had no relation with **Cyclone Komen** which originated in Bay of Bangal on July 26, 2015 and made landfall on Bangladesh on July 30, 2015.



Impoundment of reservoir started in June 2013. Water level before flood on (25.5.2015,06:00) = 669.15 ft. Reservoir capacity at R.L. 669.15 ft. = 11640 ac ft.

Due to Low pressure Trough line over Myanmar on 5<sup>th</sup> July 2015, heavy rains poured down and an extreme flood occurred in Minmyin Dam on 18<sup>th</sup> July 2015.

Rainfall measured at dam site on	7 7 2015	0.94"
Rainai measured at dam site on		0.34
	8.7.2015	-
	9.7.2015	0.59"
	10.7.2015	0.41"
	11.7.2015	0.59"
	12.7.2015	1.69"
	13.7.2015	-
	14.7.2015	2.24"
	15.7.2015	0.20"
	16.7.2015	2.09"
	17.7.2015	2.54"
	18.7.2015	10.66"
	19.7.2015	8.22"
	Total	30.17"

Spill over spillway started on (16.7.2015, 03:00) FTL = R.L.677 ft., Reservoir capacity at FTL = 19010 ac ft. Submergence of spillway bridge occurred on(18.7.2015, 09:00)

#### Incident of Dam Overtopping



တမံ Parapeteoါ်မှ ရေတျော်စီးဆင်းနေပုံ

Spill over Parapet

တမံ Parapeteol်မှ ရေကျော်စီးဆင်းနေပုံ

Dam Overtopping



ရေပိုလွှဲမှ ရေကျော်စီးဆင်းနေပုံ



ရေပိုလွှဲတံတားမှ ရေကျော်စီးဆင်းနေပုံ

#### Flood Flow over Spillway

Submergence of Spillway Bridge



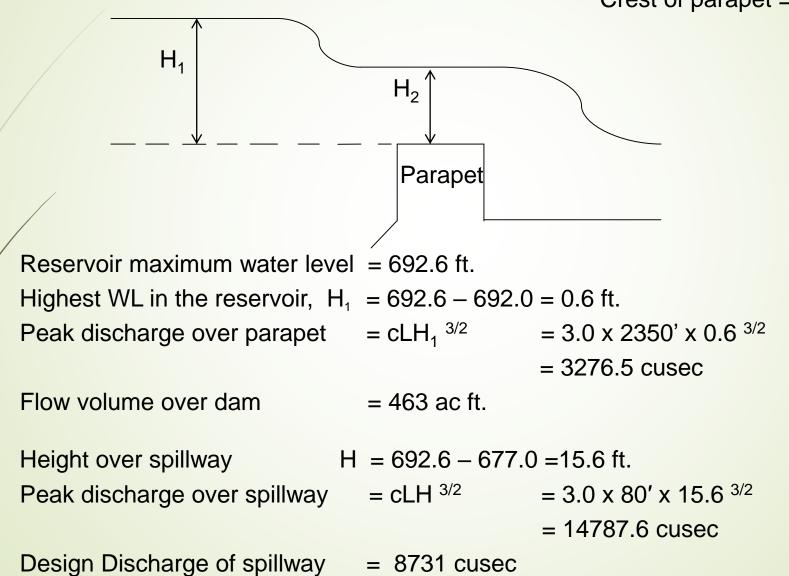
တမံ D/Sအား မြင်တွေ့ရပုံ

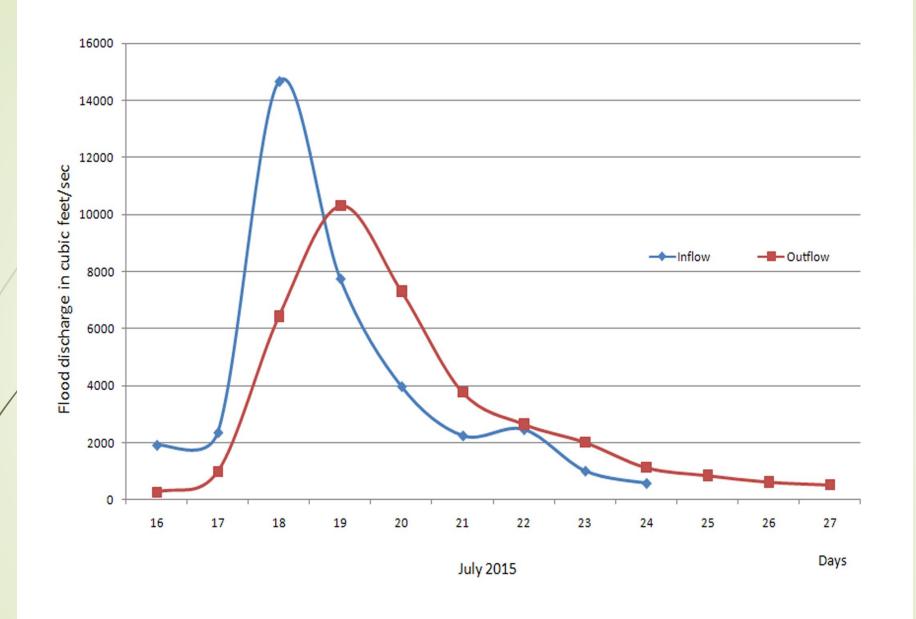
#### Dam Crest Erosion

Dam D/S Face Erosion



Duration of dam overtopping from (08:00 to 13:00) on 18.7.2015 = 5 h Maximum water level recorded on (18.7.2015, 09:20), R.L = 692.3 ft.Flood water level over dam parapet,  $H_2 = 692.3 - 692.0 = 0.3 \text{ ft.}$ Crest of parapet = 692.0 ft.





Inflow / Outflow Hydrograph

# **Calculation of Routed Flood**

**Reservoir routing** was calculated based on hourly gauge readings. In the flood

condition, an hourly gauge reading is crucial.

But it is normal practice to set up a dam gauge only up to **Design High Flood Level** and away from **spillway**.

In this incident, flood water level rising up to and over dam crest and hourly gauge

reading was done by setting up temporary gauges.

Routed peak inflow discharge	=	14667.2 cusec
Routed peak outflow discharge	=	10310.2 cusec
Inflow flood volume	=	73,381 ac ft.
Outflow flood volume	=	73,210 ac ft.
Flow volume over dam	=	463 ac ft.

Rate of water level rising on 18.7.2015 (from 02:00, 684.2 ft. to 09:00, 692.0 ft.) = 7.8 ft. / 7 h = 1.1 ft./h

Rate of water level rising is very high probably (1) Steep bed slope of river,

(2) Rainfall closer to dam.

Bed slope of river = Level difference between river head and dam site / reach of river

= (760 ft. - 602 ft.) / 24600 ft. = 0.006

 Depth
 = Flood Volume / Catchment Area = 73381 ac ft. / 64 sq. mi
 = 21.5"

 Rainfall
 = (17.7.15 = 2.54", 18.7.2015 = 10.66", 19.7.2015 = 8.22") = 21.42"
 ∴ Depth = Rainfall

#### Villages at the Downstream of Minmyin Dam

Village	Population
(1) Shan Kon	727
(2) Hin Phyutaw	292
(3) Inma	467
(4) Chaungma	77
(5) Pe Kon (Taung)	1,000
(6) Shan Su	152
(7) Ma Gyi Inn	655_
	3,370

If dam failure happens floods from Minmyin Dam finally reach to Kindat Retention Dam also.

#### **Defects on Dam**

- Scours at the toe of the parapet,
- Gullies at R.D.800 ft., 1,200 ft. and 1,600 ft. on the dam downstream face,
- (9) nos. of slope drains were damaged,
- Crest drain was damaged at R.D 1,600 ft. and 2,200 ft.,
  - 150 ft. wide slip of dam toe at R.D. 1,200 ft. due to toe drain scour,
- Eroded materials deposited on rock toe,
- No differential settlement was observed,
- No bulging was observed on dam downstream face,
- Spillway under floods seemed in good condition.

#### Some Comments on Incident

- Higher water balance in reservoir before extreme flood,
- Severe rainfall in the catchment,
- Inflow flood volume is much greater over average annual inflow and storage capacity,
- Observed routed peak inflow discharge is equivalent to observed spillway peak discharge, but much greater than design routed 1000-yr,
- Observed spillway peak discharge is almost equivalent to 10,000-yr routed discharge,
- Observed highest flood water level is almost equivalent to 10,000-yr return period,
- Observed flood volume is double to 10,000-yr return period that leads to dam overtopping,
- Shorter duration of overtopping saved dam from failure,
- Rate of water level rising was very fast due to steep bed slope of river,
- Rainfall depth is almost equal to flood depth over catchment area, it means calculated flood volume proved justified,
- Grass turfing, crest drain, slope drains and thick kankar retarded scouring to some extent, but scouring occurred when flow was concentrated at the end of overtopping,
- Scour at the toe of parapet is due to insufficient compaction in kankar laying,
- Slip at the downstream dam toe must be filled promptly,
- Parapet is excluded in dam height consideration, but 2.0 ft. parapet rendered an absorption of flood in this incident though some leakage from gaps between parapets,
- Taking freeboard as 2.0 ft. above H.F.L. (High Flood Level) is a higher risk factor,
- Wrong decision can lead to failure in such incident,
- Climate change has affected on dams in Myanmar.

#### Recommendations

- Emphasize on safe dam design,
- Importance of Emergency Preparedness Plan,
- Practice of proper reservoir operation,
- Compliance with standards and specifications in dam filling.

# Conclusion

The Minmyin Dam is affected with a flood equivalent to 10,000-yr return period.

# **Repair of Dam**

After Flood, all the damage parts were removed and **dam filling** was made on the downstream dam slope.

Dam crest was raised another 5 ft. and made proper protection on the upstream and downstream dam slopes. The downstream dam slope was slightly changed.

In addition, a 300 ft. emergency spillway was provided on the left bank.

# Thank you for your attention !