Proceedings of the national workshop on 'RESERVOIR PLANNING AND OPERATION', (19th December, 2007) organized by Civil Engineering Department, Assam Engineering College, Guwahati-781013 Under the DST sponsored project 'Planning for Optimal Utilization of Water in Three Proposed Reservoirs in North-East India'. Editor: Dr. Bibhash Sarma

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

Doyang Hydro Electric Project (3 X 25 Mw) – A Case Study

Er. H S Dutta
Deputy Manager (Civil)
NEEPCO LTD., GUWAHATI

The Doyang Hydro Electric Project, 70 Km from Golaghat on the Golaghat - Kohima Road of stretch 190 KM is located in Wokha District of Nagaland envisaging generation of 75 MW of power by installation of 3 (three) units of 25 MW each.

The Project comprises with construction of 633.00M long & 12.00 M diameter Diversion Tunnel, 428.00M long & 6.00 M diameter Water Conductor System, Approach Channel and Spillway, Rockfill Dam with Impervious Earth Core at the confluence of the Rivers Doyang & Chubi and Power House Building for installation of 3 nos. generating sets of 25 MW each alongwith Switchyard and allied structures.

The River Doyang was diverted through the Diversion Tunnel on 23.12.1996 and construction of the Coffer Dam as the first stage of construction of the main Dam was completed in Aug-1998 followed by completion of entire filling in June-2000. The reservoir impounding was commenced in the month of Jan-2000 and the first unit of the Project was commissioned in June-2000 on attainment of the reservoir level upto EL-306.00 M (MDDL) followed by commissioning of other units in July-2000.

On completion of the works of the Earth & Rockfill Dam upto its top height and pending completion of the Spillway structure upto its top height, the reservoir impounding commenced in the early part of Jan-2000 by lowering stop-log pieces of the Diversion Tunnel followed by plugging of the tunnel and lowering of the main gates in order to commission the Project. The reservoir attained the minimum level of drawal of water through Water Conductor System in mid June-2000 when activities pertaining to spinning of the units were taken up. The three Hydro Generating units each having 25 MW of capacity supplied by Bharat Heavy Electrical Limited (BHEL) was commissioned and the units were synchronised with the grid as follows**:**

1. Unit-I 26^{th} June-2000
2. Unit-II 08^{th} July -2000
3. Unit-III 10^{th} July -2000

It was proposed to commission one unit of Doyang H. E. Project by June-1998 by storing water against Coffer Dam (which is a part of the main Dam) with Coffer Dam top

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

at El-306.00 M. The Diversion Tunnel of diameter 12.00 M and length 633.00 M with rectangular opening of size 9.50 M X 12.00 M and EL- 255.00 M invert level at Intake and slope 1 in 1000 has been designed for passing 1 in 50 year flood discharge of 2298 Cum / sec.

Corresponding to reservoir level of EL-312.00 M, the discharge capacity of the Diversion Tunnel is 2297.00 Cum / sec. The top of the Coffer Dam (which was otherwise to be top at EL- 290.00 M) has been kept at the maximum practically permissible level of EL-306.00 M (MDDL) to avoid interference with raising of clay-core, cut-off trench, etc. The variation in Diversion Tunnel Capacity i.e. 2297 Cum / sec for 1 in 50 year flood to 2141 Cumecs is considered nominal and taken to stride in the interest of commissioning one unit ahead of total completion of the Project. The discharge capacity of the Diversion Tunnel is restricted to 2141.00 Cum / sec with upstream water level of EL-306.00 M. Furthermore, assuming a Free Board of 1.50 M water will be allowed to rise in the reservoir to EL-304.50 M and the discharging capacity of the Diversion Tunnel would be about 2109 Cum / sec for 100% Gate opening with upstream water level at EL-304.50 M

In view of above it was necessary to have in operation a "Flood Warning System" sufficiently upstream of the Dam - say 30 KM or so further upstream of the reservoir periphery at EL 304.50 M so that 12 to 15 hours prior notice of approaching flood is received and the Diversion Tunnel gate is opened in advance to lower / empty the reservoir to receive the flood. In this way a part of the flood would be absorbed in filling the reservoir and the remaining would pass through the Diversion Tunnel.

The Gooseneck Tunnel of diameter 6.00 M and length 32.00 M with rectangular opening of size 9.50 M X 12.00 M and EL- 287.00 M invert level at Intake and slope 45^{o} has been designed based on the model study and constructed for depleting the reservoir during operation stage when the Diversion Tunnel would have been plugged. The Gooseneck Tunnel was designed to take a discharge of 568.00 Cum / sec with reservoir water level of EL-322.50 M and 25 % of gate opening and not desirable to permit simultaneously the flow from the Gooseneck and Diversion Tunnels which may result to development of negative pressure in the Gooseneck Tunnel

Operation of Stoplogs Of Diversion and Goose Neck Tunnels:

The Stop-log gate for Diversion Tunnel was provided for a design head of 41.50 M (From EL-255.00 M to EL-296.50 M) for facilitating plugging of Diversion Tunnel after completion of Dam and other works in all respects. These Stop-log units are for one time use and are not to be retrieved. The erection of stop-log would be done in lean season with depth of water in the Diversion Tunnel not exceeding 1.0 to 1.50 M.

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

The Stop-log gate for Gooseneck Tunnel was provided for a design head of 20.75 M (From EL-285.25 M to EL-306.00 M). In normal operating condition. These Stop-log units will be kept open and operated under balanced head conditions with only the top unit to be operated under unbalanced head and to be operated for inspection between Intake and Gate Shaft.

The Emergency Gates are designed for balanced head operating condition under crack opening of 155 mm and for self closing during lowering operation in flowing water condition with reservoir level at MWL—336.00 M while in the case of Service Gates the operating criteria is for partial opening and self closing under flowing water condition for reservoir level at EL-322.50 M.

With reservoir water level at EL-304.50 to 336.00 M, it has been calculated that the hoisting capacity required for operation of Emergency Gates in unbalanced condition is about 180.00 MT against the design capacity of 200.00 MT of its hoisting equipment being provided for balance head operation against reservoir water level of EL-336.00M.

Planning for Commissioning of One Unit by June1998

The following problems are apprehended:

- Reasonable and practical risk are being taken with respect to the Coffer Dam overtopping during high flood in monsoon season with pondage upto EL-304.50 M for commissioning of one unit and a high flood of more than 2100 Cumec in the river. It has been assumed that prior intimation of flood i.e. Flood Warning System would be available so that the reservoir can be lowered / emptied before the receipt of flood. Thus installation and operation of suitable "Flood Warning System" is very important.
- While the main Dam is being raised and other works of the Project is being completed, generation of power (Stage-I) may be continued.
- The reservoir has to be emptied for plugging of the Diversion Tunnel. The plugging of the Diversion Tunnel have to be done in lean season, say in November / December and after erection of intake stop-log units of Diversion Tunnel and the plugging works have to be completed latest by February / March of the next year.
- The MDDL is at EL-306.00 M and the Powerhouse is proposed to be operated from EL-304.50 M. As per the stipulation of BHEL in the contract, against cavitation guarantee for 8000 hours the unit can be operated for only 10 % of the time during guarantee period i.e. for 800 hours. However, very efficient monitoring of reservoir level will be required in the Power House to stop the machine when water level falls below EL- 303.50 M.

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

- In the meantime, the next working season besides the other works as planned, the Rockfill Dam may be raised above EL- 306.00 M to get reservoir level of EL-306.00 M.
- During operation of Stage-I, Gooseneck should remain closed at its entry point with stop-logs.

As soon as the work of Coffer Dam with its top at EL-306.00 M is completed as also all other works for operation of Stage-I , i.e. Power House Unit-I , Water Conductor System, Erection of Stop-log at the entrance of Gooseneck Tunnel, erection of Emergency Gate in Diversion Tunnel, etc. are completed, the reservoir impounding can be started.

The reservoir capacity at EL-304.00 per meter height is of order of 10 Million Cum which is equivalent to 115.74 Cum / sec for 24 hours.

It is seen that when the river inflow discharge is 36.50 Cum / sec or more, Power can be generated for 24 Hours at 15.75 MW and when the inflow discharge varies from the minimum onwards, the generation can be done continuously for as given below and the reservoir allowed to be filled again for the next cycle:

Operation of Doyang Reservoir:

The Doyang Diversion Tunnel is designed to discharge 1500 Cumec when the water level in the reservoir would rise to EL- 285.00 M and the discharge at EL- 290.00 M would be around 1750 Cumec at the corresponding level of water in the river channel downstream of the Diversion Tunnel outlet would be about EL-259.500 M for which the downstream temporary ring bund has been raised up to 261.700 M before March-1997.

The very purpose of constructing temporary ring bund at the upstream of the Dam was for diverting lean season discharge of the Doyang River through Diversion Tunnel so that construction of the Coffer Dam could be done upto its top before the monsoon flood. Although the river was diverted on 23.12.1996, the rock filling activities on the river bed of the Coffer Dam portion could be started only in Oct-1997 on completion of foundation treatment and receding of monsoon flood water level and could be completed in 7th Aug-1998.with hand placed riprap over upstream clay core treatment.

The 1st Unit of the Project was ready for commissioning in Aug-1998 when nature played havoc at that crucial time. The Powerhouse was submerged with back water flow resulted from blockade of Doyang River caused due to massive landslide in the downstream of Diversion Tunnel Outlet. The restoration activities after the mishap as well as replacement / repair of Electrical / Mechanical equipments of the Powerhouse required an additional time of 395 days thereby directly shifting the schedule of commissioning.

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

Rescheduling of Reservoir Filling:

As per earlier programme the commencement of reservoir impounding was scheduled in Sep-'99 in order to commission the Project. The Panel of Experts studied the proposal during their 4th sitting at the Project site on 10.04.1999. After detailed deliberation, the POE suggested to commence the reservoir filling from Dec-'99 in stead of Sep-'99 since the
borrow areas / quarry areas were located in the proposed reservoir area much below the level of the Spillway crest of EL-321.00 M. This would help to raise the Rockfill Dam above the Spillway crest level for its safety during flood season of 2000 and this would also squeeze overall construction schedule of the Rockfill Dam with Impervious Earth Core..

The reservoir impounding had to be further deferred in view of the protest made by the local villagers residing across the Chubi River as lowering the stoplog of Diversion Tunnel would cut-off the communication link till completion of the Bailey bridge over River Chubi. Marboats were therefore provided as a means of temporary communication till completion of the said Bridge. The villagers also resisted lowering of the Diversion Tunnel Stoplog units on 02.02.2000 when last leaf of the Stoplog was being erected. However, lowering of all the units of the Stoplog could be completed on 09.02.2000 thereby commissioning of full reservoir filling.

Due to various reasons, the jungle clearance activities from the reservoir could not be taken up. However there were hardly any chances for jungle, trees, etc. below MDDL to decay with submergence whereas the same may decay in the area above MDDL to FRL which would keep on rising and falling every year. During the flood season of 1995 a temporary trash rack was provided at the approach channel of the Diversion Tunnel to arrest the debris coming from the reservoir area. But the same was dismantled as it could not withstand the load of the logs, trees etc. and all the debris were passed through the Diversion Tunnel.

On 22nd Mar-2000 onwards , it was observed that the decayed trees and jungles were floating towards the Dam. It was apprehended that the trees, jungles from the catchments area of the reservoir / above the reservoir may also be floating towards the Dam site during floods. It was decided to have a Floating Pontoon, Logboom from one abutment to the other upstream of the Dam where such floating trees, jungles, vegetation, etc. can be intercepted and carted out of the reservoir. It was also considered that the grass and twigs (fine trash) may still pass under the Logboom and gets collected at the Water Conductor System Intake Trash Rack which are required to be clean everyday

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

during rainy season and periodically during the remaining part of the year with a boat and its crew with suitable disposal arrangements.

Plugging of Diversion Tunnel:

The work of lowering of stoplog was taken up in the 1st week of Jan-2000. However, heavy leakage underneath the stoplog was noticed. In anticipation that the stoplog pieces did not sit properly over the grooves resulting to heavy leakage, repeated lifting and lowering were done with little effect. The grooves were inspected when it could be seen that lot of
spoils with boulder pieces were deposited over the grooves, necessitating its clearance to ensure sitting of the stoplog pieces in air tight manner. However, the debris cleared used to get replenished by flowing water by the time the stoplog pieces are lowered and therefore the leakage underneath the stoplog could not be arrested effectively. As limited time was available for plugging the Diversion Tunnel before onset of monsoon and the stoplog pieces are non-retrievable, to tide over the crisis it was ultimately decided to dump impervious materials at the upstream of the stoplog so as to block any flow of water. This could be successfully done and the flow through the tunnel could be stopped successfully.

The work of putting the concrete plug which involved construction of shear key along the circumferential periphery with roughening of the contact surface, anchorage, etc. along the periphery of the concrete lined Diversion Tunnel was taken up before lowering stoplog and could be completed by 15.02.2000 after lowering of stop-log.. The shear key along the periphery of the Diversion Tunnel could not be provided during concreter lining works as it was apprehended that cavity may be formed with the flow of water through the tunnel. The downstream end of the concrete plug was given ogee shaped profile for smooth stream lined entry of water from Gooseneck Tunnel and the length of the straight portion of the concrete plug is twice the diameter of the Diversion Tunnel. One 3// diameter pipe fitted with a valve and another of same diameter pipe were placed at the bottom and crown levels of the plugging portion respectively to allow the seepage water and the air entrapped in between the stop-log and the upstream steel shuttering. The valves were closed on completion of the plugging activities..

The plugging work was a challenging task as the same was required to be completed in a very time bound manner before the reservoir attained the El- 309.00 M, the operating platform for Gooseneck stoplog pieces, as otherwise the stoplog pieces installed at the intake of Gooseneck, which are of retrievable nature could not be operated. Furthermore, since the Gooseneck stoplog pieces were designed for a

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

maximum head upto EL-309.00 M, it was not desirable to allow impounding against these stop-log pieces beyond EL-309.00M.

A study conducted on the basis of available discharge data collected for 9 (nine) years from 1991 to 1999 during the construction of the Project to ascertain the probable time that would be required to fill the reservoir from EL-255.00 M to EL-306.00 M (MDDL) based on the Area Capacity Curve which indicated that about 45 to 60 days would be available. It was found that the time required to fill the reservoir level upto EL-309.00 M from EL267.00 M i.e. the top of upper most stoplog piece installed in the inlet of the Diversion Tunnel, would be of the order of 30 days, which had necessitated completion of plugging work positively within 30 days.

The plugging work commenced with the arrangement for dewatering the standing pool of about 1.50 M depth within the Diversion Tunnel which was created due to the raised crest of flip bucket. On being rendered the tunnel dry after dewatering and filling of the invert portion with spoils, the work of concreting was taken up and with all out efforts the plugging work could be completed in all respect within the schedule time.

Repair of Service and Emergency Gates of Diversion Tunnel:

During the process of reservoir impounding, leakage beyond the permissible limit (15 Litre / minute / running meter of seal) was observed through the Diversion Tunnel Gates. The following activities are planned to be taken after the reservoir is depleted upto the bottom level of the Gooseneck Tunnel i.e. EL-290.00 M

- The reservoir water level as on 15.11.2002 was EL-316.00 M and with the running of Powerhouse, the reservoir was receding 15 to 20 cm per day and would take 40 days w. e. f. 01.12.2002 to recede to MDDL-306.00 M when the Powerhouse would be shut down in order to take up mandatory inspection of the runners as per the suggested guidelines of the manufacturer of the machines.
- The reservoir was depleted w. e. f. 06.03.2003 and rectification works of Gates has been taken up after depletion of reservoir upto EL-290.00 M.
- After attaining the reservoir level at MDDL, both the Service & Emergency Gates were lifted to deplete the reservoir upto EL- 290.00 M i.e. at the invert level of the Gooseneck face.
- It was observed from last few years that the discharge through the Diversion Tunnel from mid January to March was around 10 Cumec.
- For diverting the discharge from Gooseneck to Diversion Tunnel 3 (three) leaves out of 4 (four) leaves of stop-log at the Gooseneck face were lowered to get about 10 (ten) working days inside the tunnel to accumulate at the upstream of the stop-log. On accumulation of water around the mid of the 3rd stop log leave, 2nd & 3rd

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

leaves were regulated periodically by a mobile crane to allow the water to pass through the Diversion Tunnel and again put in position to get another 10 (ten) working days inside the Tunnel.

- The process of lowering and lifting of stop-log continued for about 40 days till rectification works were over and the Service Gates were put in operation by resting on its bottom seal to impound reservoir upto the designed levels. As the stop-log leaves are to be operated in balanced head conditions the 2nd & 3rd leaves could be lifted / retrieved ultimately in very difficult situation and the 3 (three) stop-log leaves were kept apart in the downstream area keeping the 1st one to rest in position of the stop-log grooves. .

All the units of the Doyang Hydro Electric Project are running in full swing with generation of power upto the mark

SALIENT FEATURES
DOYANG HYDRO ELECTRIC PROJECT

1.	Name of the Station	:	Doyang Hydro Electric Project
2.	Name of the River	:	Doyang
3.	Location		
	a) State	:	Nagaland
	b) Nearest Railway Station	:	Furkating, Assam
	c) Longitude		$94^{o}\ 15^{/}\ 58^{//}$
	d) Latitude		$26^{o}\ 13^{/}\ 47^{//}$
4.	Reservoir		
	a) Type of Dam	:	Rockfill with Impervious Core
	b) Height of Dam	:	92.00 M at deepest section
	c) Length of Dam	:	465.00 M
	d) Catchment Area	:	2606.00 Sq. KM
	e) Full Reservoir Level (FRL)	:	333.00 M
	f) Mix[m.] Draw down Level (MDDL)	:	306.00 M
	g) Storage Capacity at FRL	:	535.00 MCum
	h) Storage Capacity at MDDL	:	165.00 MCum

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

i-) Effective Storage	:	370.00 MCum
5. Water Conductor System		
A. Head Race Tunnel		
a) Length	:	427.26 M
b) Internal Diameter	:	5.90 M Circular & Steel Lined
c) Slope of Invert	:	50^o with Horizon at the inclined portion
d) Discharge Capacity	:	150.00 Cum
B. Open Channel		
a) Length	:	100.00 M
b) Bottom Width	:	20.00 M
c) Side Slope	:	1 V : 4 H
d) Slope of Invert	:	1 : 100
e) Maximum Discharge Capacity	:	150 Cumec
C. Penstock Valve		
a) Type	:	Lattice Type Butterfly Valve
b) Diameter	:	2.90 M
c) Number	:	3 (three)
d. Penstock	:	Head Race Tunnel Steel Lined with double bifurcation feeding to three Turbines.
6. Powerhouse		
a) Surface / Underground	:	Surface
b) Length	:	69.50 M
c) Breadth	:	28.25 M
e) Ground Floor Level	:	264.50 M
f) Central Line of Distributor	:	248.80 M
g) Capacity of EOT Crane	:	100MT / 25 MT

SALIENT FEATURES
DOYANG HYDRO ELECTRIC PROJECT

7. Water Turbine		
a) Number		3 (three)
b) Type	:	Francis
c) Make	:	BHEL
d) Head		
i) Maximum	:	83.50 M
ii) Minimum	:	43.50 M
Iii) Rated	:	67.00 M

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-3, December 2013

	iv) Designed	:	67.00 M
	e) Rated Output of each Unit	:	25 MW
	f) Normal Speed	:	250 RPM
	g) Runaway Speed	:	510 RPM
	h) Diameter of Runner	:	2.35 M
	i) Efficiency at 100% Rated Load	:	91.40 %
8.	Tail Race		
	a) Type	:	Channel
	b) Size	:	20.00 M X 6.50 M
	c) Length	:	52.00 M
9.	Generator		
	a) No. of Units	:	3 (three)
	b) Type	:	Salient Pole / 3 Phase / Synchronous
	c) Make	:	BHEL
	d) Voltage	:	11 KV
	e) Capacity	:	25 MW
	f) Current	:	1458 Amp.
	g) Speed	:	250 RPM
	h) Efficiency at 100 % Load	:	96.71 %
	i) Excitation System	:	Static, Tyristorised
10	Transmission Lines	:	110 / 132 KV
.			