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Construction of Surge Shaft by Slip Form for a 330mw Hydropower Project at Kishanganga in J&K

Mohammad Adil Dar[1], Prof (Dr) A.R. Dar [2] , Shazia Shafi Bhat[3] , Jayalakshmi Raju[4] ,Manzoor Shafi Bhat[5]

[1&4] *PG Scholar, Department of Civil Engineering, Kurukshetra University, Haryana, India*
[2] *Professor & Head, Department of Civil Engineering, NIT, Srinagar, India*
[3&5] *PG Scholar, Department of Civil Engineering, NIT, Srinagar, India*

Abstract: *Surge Shaft is one of the essential components in hydro power construction involving long running HRT (Head Raise Tunnel)so also with moderate to high head. It is generally a reinforced concrete lined, circular, open to sky or underground (but connected with tunnel opening to atmosphere), with a orifice slab at bottom where the HRT terminates and pressure shaft(s) (PS) begin(s), also with the controlling gate(s) for PS(s). Function of the surge shaft is to negotiate the sudden surge generally know as water hammer pressure generated due to rapid fluctuations in the flow of water through the tunnels. Slip form is a self-contained formwork system that may require little crane time during construction. It is an element used in method of vertically extruding a reinforced concrete section. In this construction method, concrete is poured into a continuously moving form. Slip forming[1] enables continuous, non-interrupted, cast-in-place "flawless" (i.e. no joints) construction which have superior performance characteristics to piecewise construction using discrete form elements.*

Key-words: *Essential component, Sudden surge, Non interrupted, Discrete form.*

I. Surge Shaft Concreting

Procedure

Surge Shaft is to be built at the junction of HRT) & upper horizontal pressure shaft (UHPS). For the construction of same both HRT & UHPS shall be excavated up to the junction so also the surge shaft shall be excavated up to bottom of the orifice slab. Once the excavation is complete and junction is supported, the orifice slab including starter ring beam will be constructed by using conventional staging and shuttering[2][4]. With the starter beam casted, that acts as a reference for the slip form works, the concrete lining will begin from bottom upwards. Surge Shaft concrete lining using slip form will be inclusive of first stage gate groove concreting. Considering the starter ring beam of 1.5 to 2 m rise, slip form concreting will possibly begin from Elevation 2326.5 and will last up to Elevation 2425.7 which is around 99.2 m.

Survey & Marking

Before starting the concreting works for surge shaft, the excavated surface with reference to the center line shall be checked and suitably treated for any undercut which may halt the slip form movement and thereby may hinder the concreting work. Reinforcement at different levels is different due to varying lining thickness. Markings at the correct intervals indicating the change in the thickness will help the fitters laying reinforcement and will ease the form work handling. So also with varying thickness of lining, the markings done to identify them will also guide about the varying concrete quantity requirement.

Shuttering & Staging Arrangement For Orifice Slab

Conventional staging and shuttering will form the assembly for concreting of orifice slab. Though the assembly is conventional type but the thicker slab, heavy and complex reinforcement and monolithic casting necessitates the stronger shuttering and matching staging forming a capable & stable assembly. It is necessary that sufficient tie-beams to ensure stability of the assembly should be tied. So also to ease the laying and maintaining of concreting pipeline through the orifice shall the sufficient passes and pockets be left in the assembly. Considering most of these aspects in addition to the design calculations, the shuttering and staging arrangement has been planned and shall be supplied in details along with the drawings, by corresponding department. FIGURE -1 shows a view from the bottom of the surge shaft from inside. FIGURE-2 shows top view during reinforcement

Figure-1

Figure-2

Orifice Slab Concreting

- Once the assembly is set up as said above and reinforcement is laid as per the reference drawings, the concreting pipeline arrangement will be put in place.
- Concreting will be tackled by pump from bottom as well as by using the specially designed concrete carrying bucket from top using gantry crane.
- Since the concrete volume to be poured is more and reinforcement is heavy as well as complex, it is necessary that fresh concrete is vibrated properly to settle in layers and thereby avoiding the voids.
- Cover blocks will be put in place to maintain the specified cover of the concrete. Sufficient numbers of cover blocks at appropriate intervals will be laid in order to avoid any sag or buckling of reinforcement cage/bars.
- The 16 mm thick liner will be put in position by tacking with the reinforcement bars so also by cross bars from inside to ensure stable position and correct embedment.

Slipform Assembly And Installation

- Along with the hydraulic system, the slip form[3] unit will be assembled inside the shaft at the starter location at the bottom of the surge shaft just above the orifice slab.
- First the unit (form & allied) will be assembled and then the hydraulic system will be fixed. This assembly will be done by suspending it with the help of installed gantry on the working platform.
- This unit will be suspended from four or more points as required so that it remains in a level plane and hence can be assembled easily and coaxially without getting tilted on one side.
- Once this unit is assembled fully at the starter ring beam, the hydraulic system consisting of power packs, connecting hoses, jacks, jack rods etc. will be fixed in position.
- Alignment will be carried out after the slip form unit is completely assembled and datum points for plumb / center will be established.
- The slipform design/shape at the gate groove portion will be made slightly rounded at the edges to facilitate the shutter manufacturing.
- The round-off edges will be matched up to the final shape during the second stage concreting at gate groove portion.The slipform maintenance schedule will be followed as specified by the supplier.

Concrete Lining By Slip-Form And Supply Arrangement

- As mentioned earlier concreting for lining work will be tackled from both, top and bottom accesses to the surge shaft.
- For concreting, when concrete is being conveyed using bucket from top it can directly be poured along the periphery. Whereas, when to be pumped from bottom to top, a pump installed at bottom tunnel will convey the concrete via a pipeline laid to a platform. Any other suitable method as per the site conditions, other than the two mentioned above may be selected for concreting, ensuring its techno- commercial viability.
- Batching plant of 30 cum/hr, near TBM adit will be the source for specified concrete grade. Concrete will be poured in layers of 200 mm for proper finish and working of slip form unit. Four such layers will be put to achieve 800 mm lift / pour sequence. The shutter height will be 1 m.
- The needle vibrators will be used for suitable compaction of concrete in each layer.
- The speed / progress of concrete pour will be so adjusted that the next layer will be placed while the previous layer concrete is still green. Prior to the concreting of the next layer the general good construction practices like cleaning the shutters and oiling will be followed.

- The setting time of the concrete in low temperature conditions will be adjusted by use of hot water or admixtures. Suitable curing arrangements will be done to mitigate the heat of hydration and thereby achieve the desired strength of concrete.
- The initial setting time at the required slump will be min 30 min and restricted to 2 hrs. Temperature of concrete during pouring will be maintained between: 20 to 250C.
- Final concrete lining strength will be 25 MPa at 28 days.

During the first stage concreting the embedment will be fixed as per the approved drawings and thorough checks will be conducted for its fixing proportions and allied technical parameters.

Anti Rotation Measures & Gate Groove Verticality Monitoring

- Anti rotation measures will be taken to maintain the slip form assembly in steady and correct position in every slip/lift.
- Sometimes due to untraceable unbalancing forces the formwork tends to rotate about the central axis. To avoid/control this rotation, the anti-rotation measures have been proposed.
- The deviation from the fixed points on circumference will be constantly monitored, using laser survey equipment.
- To avoid/control the rotation the timely observation of deviation from theoretical X &Y location at all the points in space at every 0.5 m level difference is extremely essential.
- In order to have continuous check up for verticality & twist, there will be a proper monitoring from the bottom of the shaft. For the same, a passenger movement assembly (like a protective & safe for movement cage) will be required.
- The verticality maintenance & monitoring device consists of a trailing structure, 3.5 m, which hangs below the level of shutter bottom, almost like a dummy gate that arrests the tilt by the basic principle of structural geometry.

II. Conclusion

Surge Shaft for Kishanganga Hydropower Project located in the state of J&K in district Bandipora was successfully constructed to negotiate the sudden surge generally know as water hammer pressure generated due to rapid fluctuations in the flow of water through the tunnels. Slip forming enabled continuous, non-interrupted, cast-in-place construction which have superior performance characteristics to piecewise construction using discrete form elements. Smooth construction was ensured throughout all the phases by following the necessary guidelines.

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Author Details

M Adil Dar

The Author has received his B.E(Hons) in Civil Engineering from M.S.R.I.T Bangalore. He is Presently pursuing his M-Tech in Structural Engineering from Kurukshetra University. The Author has published papers in numerous High Quality Peer Reviewed International Journals and International Conferences. His research interests include Earthquake Engineering, Bridge Engineering & Steel Structures. He is a Chartered Engineer from Institution of Engineers, India & Chartered Structural Engineer from the Institution of Structural Engineers. He is the Fellow of IAEME, IIBE & ICC(CIDC) & Life Member of ISE(I), ISET, ICI, IBC, ISSE, ISCA, ISTE, ISTAM, ISRMTT, IndACM , IE(I), IAENG, , IET(U.K) & Member of IAStructE, IABMAS(Italy), IStructE, ASCE,IE(Ireland) & IEAust.

Prof(Dr) A.R.Dar

The Author has received his B.E in Civil Engineering from R.E.C Srinagar (Presently N.I.T Srinagar) , M.E (Hons) in Structural Engineering from I.I.T Roorkee & Ph.d in Earthquake Engineering from University of Bristol U.K under prestigious Commonwealth Scholarship Award. He is presently working as a Distinguished Professor & Head of Civil Engineering Department in N.I.T Srinagar. The Author has published papers in several International journals & Conferences. His research areas include Earthquake Resistant Design, Tall Structures, Structural Dynamics , RCC design, Steel Design & Prestressed Design . He is the Life Member of several professional bodies in structural engineering. He was the Advisor in UPSC Board 2011 for conducting interviews of IES candidates .He was also empanelled as Paper setter & Examiner for Public Service Commission ,Himachal Pradesh in Civil Engineering. He is presently the Senior most Professor & holds many administrative responsibilities in the same institution.

Jayalakshmi Raju

The Author has received his B.E(Hons) in Civil Engineering from M.S.R.I.T Bangalore. She is Presently pursuing her M-Tech in Structural Engineering from Kurukshetra University.. She has published many papers in numerous peer reviewed International Journals and International Conferences. She has presented technical papers in many State & National Level Technical Events. She has also participated in many technical events like cube casting & technical debates. Her research interests include Steel Design, RCC Design & Bridge Engineering. She is the Fellow of IAEME & member of ASCE, ACI , IEAust , SEFI, & ISCE.