Accelerated Development of Hydro Power

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ABSTRACT

The socio-economic growth of nation is dependent on exploitation of available energy resources to its fullest and in particular hydropower, as a clean renewable source of energy, which is an essential need of any developing country. India, one of the fastest growing economies, is blessed with immense hydro-electric potential and ranks 5th in terms of exploitable hydro-power potential on global scenario. India is endowed with economically exploitable hydro-power potential of 1,48,700 MW of installed capacity. In the present scenario, the generating installed capacity is only about 26% of hydropower potential i.e. 39,340 MW. The pace of Hydropower development in India has slowed down especially in last few decades. Slow development is primarily attributed to long gestation period, lack of funds, complex geology of the projects etc. Therefore, to meet country's energy demand at faster pace, development of mega hydropower projects is required, which warrants *the need of innovative practices in construction & design aspects integrating project management, engineering and quality management tools & techniques,* for making up the loss, as far as possible. *The pioneering practices in discipline of construction & design are blended and incorporated in an innovative hydropower model, envisaged for accelerated development of hydropower.* For better comprehension of the model for hydropower projects, it may be split into the four aspects i.e. Technical, Financial, Policy and Infrastructure. *A typical triangular shaped model proposed as "7M MODEL" is being devised based on the experiences learnt during the planning, execution and operation of successful Mega hydro-electric projects.* The 7M model is well knit structure, which would ensure timely and successful completion of any Hydro-electric project involving various aspects on technical, financial, infrastructure and policy matters. The 7 M's of 7 M model are Master Planning, Money, Manpower, Machinery/Material, Moment, Monitoring and Mid-course correction, which steers the fate of project. It can definitely play a lead role for setting up of blue print towards accelerated harnessing of hydropower potential and ensure the path of achieving the dream of 100% exploitation of hydropower potential.. This innovative 7 M model is time tested which is the backbone of a success story in construction and commissioning of mega hydroelectric project in Bhutan i.e. Tala hydroelectric project (1020 MW), the project located in the toughest ruggid terrain of Himalayas, besides backed up by similar numerous projects. The mega hydroelectric projects in pipeline i.e. Punatsangchhu-I (1200 MW) and Punatsangchhu-II (1020 MW) in Bhutan which are targeted to be completed on scheduled timeframes are also following the similar principles of 7M Model. Therefore, the *7M Model well integrating state-of-the-art innovative practices adopted in construction & design aspects* may be viewed as a typical role model for ensuring accelerated hydropower development all across the nation.

1. INTRODUCTION

India, one of the fastest growing economies, is blessed with immense hydro-electric potential and ranks 5th in terms of exploitable hydro-power potential on global scenario. India is endowed with economically exploitable hydro-power potential of 1,48,700 MW of installed capacity.

Presently, the generating installed capacity is only about 26% of hydropower potential i.e. 39,340 MW. The conceptualization and execution of Mega Hydro Electric projects at an unprecedented pace is the need of an hour, before the rift between demand and supply scenario of electricity could reach a critical point. This warrants construction of projects in more rugged, inaccessible, geologically difficult sites, where the alternatives for better site selection are limited. The circumstances arising out of compulsion of utilization of the available remaining sites necessitates compensating it with invent of state of art technology, suiting to ground conditions and functional requirement. This implies that the technology imbibing innovative practices in construction and design aspects, more responsive to geological conditions & geotechnical parameters fulfil the construction standards and meeting technical requirements is the solution to this challenge. All these aspects affecting the pace of hydropower development have been well knit in a model "7M" which ensures the accelerated development of hydropower projects. This paper briefly deals with the related issues.

2. EXISTING SCENARIO OF HYDROPOWER IN INDIA

In India about 56 number of pumped storage projects have also been identified with probable installed capacity of 94,000 MW. In addition to this, hydro-potential from small, mini & micro schemes has been estimated as 6,782 MW from 1,512 sites. Thus, in totality India is endowed with hydro-potential of about 2,50,000 MW. However, exploitation of hydro-potential has not been up to the desired level due to various constraints confronting the sector.

As India continues to grow and develop, dependable and reliable energy sources become a pre requisite. In order to achieve the targeted capacity addition, the central government along with various state governments has taken significant initiatives for development of power projects in both public as well as private sectors, with special emphasis on development of hydropower potential of the country to keep a balanced mix of thermal and hydro power generation. The Challenges in present scenario for speedier Hydropower Development are summarize as follows:

1. Investigations in minimal time
2. Race against time – Deadlines / Time Schedule
3. Heterogeneous Geology
4. “Speedier” Implementation of Project
5. Implementation of Activities in Concurrent Mode

3. NEED OF SPEEDIER HYDROPOWER DEVELOPMENT IN INDIA

Hydropower has had slow development in India especially in last few decades. The Slow development could be primarily attributed to:

– long gestation period and time consuming process for project clearances,
– highly capital intensive and lack of committed funds,
– poor financial health of State Electricity Boards (SEBs),
– Technical constraints due to complex geological nature of the projects
– inter-state disputes as Water is a state subject
– dearth of competent contracting agencies to construct the project

Therefore, to meet country’s energy demand at faster pace, development of Mega hydropower projects are required, which warrants the need of an Innovative Hydropower Model. Every Hydropower Project comprises the following stages as shown in Figure - 1.

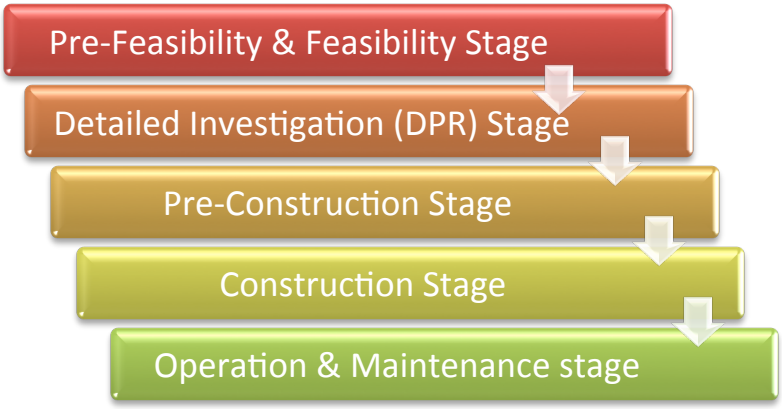

Figure 1: Stages of Hydropower Project

These Stages are much interdependent on each other. Hence timely completion of these stages becomes critical. For successful achievement of any hydropower model these stages requires continuous monitoring, planning and review which may be knit in the form of a Hydropower Model.

4. AN INNOVATIVE MODEL :7M MODEL

Based on practical difficulties and experience a typical model triangular shaped proposed as "7M MODEL" is being devised. The strategies followed and adopted during the Hydropower development in Bhutan during execution of Mega projects i.e. Tala H.E. Project (1020 MW), Punatsangchhu-I H.E. Project (1200 MW) and Punatsangchhu-II H.E. Project (1020 MW) have been incorporated in this Model. The Model itself proves successful which is evident from successful completion of Tala H.E. Project, and ongoing Punatsangchhu-I H.E. Project and Punatsangchhu-II H.E. Project which are targeted to be completed as scheduled. A structure of 7 M model is depicted in Figure – 2.

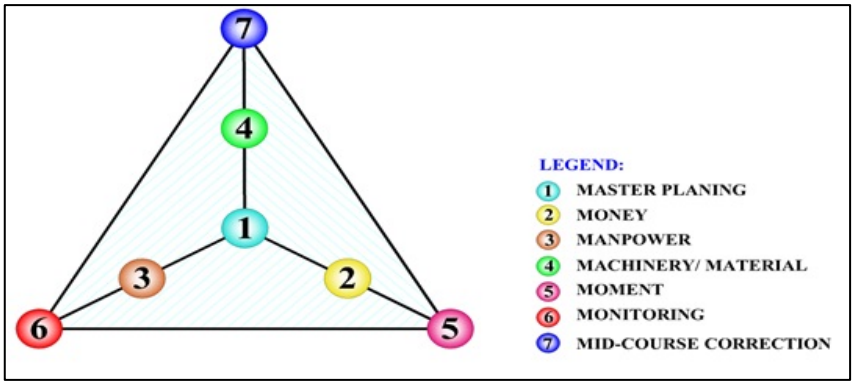

Figure 2: Structure of 7 M Model

5. Aspects of 7M Model

The 7M model may be split into the four aspects as shown in Figure - 3. It is essential that problems coming on the way of harnessing the hydro potential be removed. Presently, challenge is to develop hydro resources in Himalayan belt, which are of comparatively poor geology and have silt related problem. Due to obvious reasons construction period and cost of these sites, which are also having problem of infrastructure, will be higher. Various aspects influencing the functionality of 7M model are broadly categorized as below:

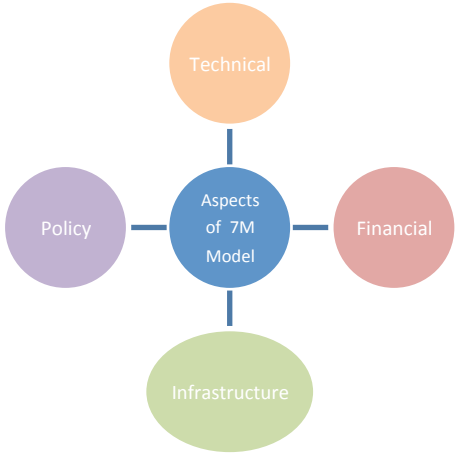

Figure 3: Aspects of 7M Model

5.1 Technical Issue

Technical Issues proposed in the model are to be anticipated at the planning and detailed investigation stage only which are addressed as below:

5.1.1 Reliable and Bankable Detailed Project Report

To expedite early execution of hydro projects, bankable Detailed Project Report (DPR) based on detailed survey should be prepared to avoid geological uncertainties. Survey & investigation and

analysis of geological, geo-morphological, geo-electrical, hydrological data etc. should be done at the time of preparation of a DPR itself in order to minimize the impact of risks. The quality of DPRs should be of high standard which should infuse confidence in the national/international developers to take up the execution of projects contract monitoring as distinct from project monitoring should be emphasized and land acquisition and infrastructure development be settled and completed before the start of the project.

5.1.2 Construction Time

Construction time is another area of concern, which needs to be compressed. Large projects have taken inordinately long time. There are two major aspects which could make a difference – one is relating to construction management techniques starting from planning to monitoring and another relate to construction technology. Based on the benchmarks which have been established, the techniques and technologies shall be further improved. Choice of technology will have to be given serious consideration

5.1.3 Geological Surprises and Challenges

Generally, in Himalayas, the geological challenges faced during hydropower development are being shown in Figure - 4. The features of the hydro-electric projects, being site specific, depend on the geology, topography and hydrology at the site. Even when extensive investigations using state-of-the-art techniques are undertaken, an element of uncertainty remains in the sub-surface geology. The geological surprises during actual construction cannot be completely ruled out which inter-alia result in cost escalations and time over runs.

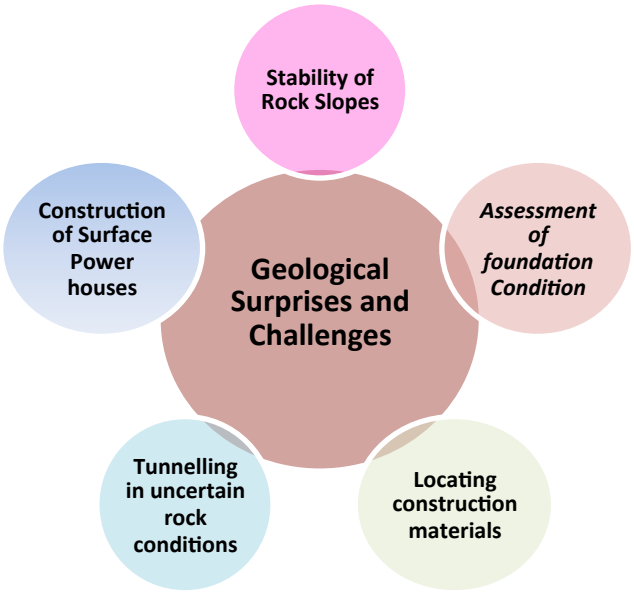

Figure 4: Geological Surprises and Challenges

Geological surprises could be minimized by adopting suitable means during planning & investigation stage and during construction stage. During planning stage, the suitable project specific programme of investigations has to be planned and there should be regular interaction amongst planning, design & engineering formations with engineering, geology and geo-physical experts.

5.2 Infrastructural Issues

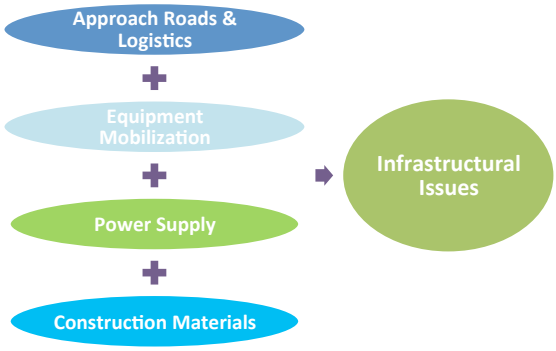

Figure 5: Infrastructural Issues

Development of infrastructural facilities in hydro rich States needs to be planned so as to facilitate hydro development in these States. Moreover the infrastructure issues which are being looked in 7M Model are being shown in the Figure - 5.

5.2.1 Approach Roads & Logistics

It is proposed that either the roads be constructed and paved by the Project Developer before inviting tenders, or that additional time be allowed to the main Contractor to perform this work effectively. The Contractor facilities such as access road, officer / labor accommodation, power, water supply construction equipment etc should be in place well in time. For development of hydro electric projects located in the remote areas, infrastructural facilities like construction of bridges, strengthening of existing roads, efficient and reliable tele-communication links, better road transport / air services etc. are required for their early implementation.

5.2.2 Equipment Mobilization

Therefore feasibility and viability of fastest mode of transport for equipment mobilization at site like helicopter may also be looked at during the DPR stage only, which may not affect the cost benefit ratio at large. Even the minimum required equipment could be purchased by the project developer well in advance and modified at contractor cost as per his choice and the supply of equipment could be matched with award of works to have a head start right in the beginning

5.2.3 Power Supply

Project Developer should arrange one or more diesel power plants of sufficient capacity to meet the Contractor's legitimate needs, and inform the Contractor of the proposed charges for supply of power, so that adequate cost can be reflected.

5.2.4 Construction Materials

The responsibility for supplying construction materials can be taken over by the Project Developer, as it may be cheaper for the developer to perform this role. Further making the construction material available continuously since the beginning of the work will help in timely completion of the job.

5.3 Financial Issues

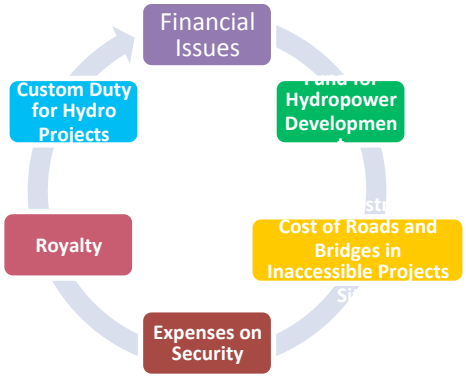

Figure 6: Financial Issues

The 7 M Model resolves the financial issues pertaining to the issues shown in Figure - 6 in following way:

5.3.1 Need of Creation of Fund for Hydropower Development

The cost of report preparation would be recovered from the developer to whom the project is allotted. It is essential to have investment attracting concession agreement that may attract big private players in hydropower development. With a view to bring in additional private investment in the hydel sector there would be a greater emphasis to take up schemes through the joint ventures between the PSUs/SEBs and the domestic and foreign private enterprises.

5.3.2 Heavy Construction Cost of Roads and Bridges in Inaccessible Projects Sites

The cost of access roads should not be included in the project cost, as development of hydro projects triggers economic and commercial activities around the project site and results in economic benefit to the State. At present, the cost of road development is borne by the hydroelectric projects which increases the construction cost of the project and thereby high tariff.

5.3.3 Off- Loading of Expenses on Security

There is also a need to off-load indirect cost components on hydro project. Many hydro projects are located in troubled areas and infested by militancy and terrorist activities. However, the recurring expenditure incurred on security, once a project goes on stream could to be charged on the project developer. As the law and order is the responsibility of the State, the cost of security may be borne by the State/Centre.

5.3.4 Royalty

Since the hydroelectric projects provide 12% free power to State, the royalty on quarry material can be exempted.

5.3.5 Exemption of Custom Duty for Hydro Projects

There is relief in custom duty for imported equipment and machinery for Mega projects. For all hydroelectric projects the custom duty may be exempted for imported equipment and machinery.

5.4 Policy Issue

The audacious and effective policy is required for accelerating the hydropower development. Hence the 7 M Model undertake the policies in the following way:

5.4.1 No Delay in Clearances

It will be desirable to have a single window dispensation/authority so that a project is cleared without many hassles. The Ministry of Power may have a set up for hydro projects cleared from all the angles.

5.4.2 Selection of Project Developer

The Selection of Project Developer is an important issue. Since hydropower projects involve huge investment and time, the hydro projects which involve lesser risk element and entail lesser capital investment can be considered for development in the Private Sector. Public Sector can take up (a) Multi-purpose Projects (b) Projects Involving inter-State issues and in inter-State river systems, (c) Projects involving cooperation with neighboring countries and (d) Projects for complementary peaking with regional benefits (e) Projects in the North-Eastern Region etc.

5.4.3 Inter-state Disputes

Unfortunately, the inter-state disputes over the sharing of river water have become almost un-resolvable. Due to such problems, it is becoming difficult to finalize the down stream discharge during the lean period making the operation of multipurpose reservoir complex. If all major rivers are made National sources and its water is distributed by Centre keeping the requirement of States in mind, the time may be saved.

5.4.4 Private Land Acquisition

The land acquisition for hydroelectric project is a time consuming process. The work of land identification, its physical verification and preparing papers for private land acquisition is cumbersome. This not only involves time but it becomes almost impossible to predict when the possession of private land can be obtained and at what cost. .

5.4.5 Law & Order / Militancy Problems

Most of the Hydroelectric Projects are constructed in hills or on foothills which may be affected with law & order/ militancy problems. The local administration may come forward for protecting and encouraging the agencies involved in activities for construction of Hydroelectric Project.

5.4.6 Rehabilitation & Resettlement (R&R)

The Rehabilitation & Resettlement (R&R) of Project Affected People (PAP) is another major issue affecting the smooth execution of hydroelectric projects particularly wherein submergence areas, the number of project affected people are large. Therefore hydroelectric developing agencies may keep provision of suitable employment for project affected families in its R&R plan.

5.4.7 Encouragement of Public and Private Sector Participation in Hydropower Development

With the view to tap the hydropower potential, huge investment is required. In this context, bridging the gap in availability of funds and requirement of funds has become critical and consequently, large projects are being undertaken in different segments of the sector; Generation, Transmission and

Distribution. Hence there is urgent need of Public and Private Sector Participation for accelerated development of Hydropower projects keeping the pace with the quality and time. A clear road map needs to be drawn, particularly for the Independent Power Producers (IPPs) and Public Private Partnership (PPP) hydro projects so that their financial closure is achieved at the earliest possible.

5.4.8 Technical Knowledge Development

While awarding contracts to foreign agencies, it should be ensured that transfer of technology programme forms part of agreement so that Indian Engineers can get training for new technologies, make aware themselves about new developments and see the physical implementation of new technology at-site.

5.4.9 Dearth of Competent Indigenous Construction Agencies

There is a dearth of competent contracting agencies having sufficient technical, managerial construction and financial resources required for undertaking Mega hydroelectric projects. This is due to absence of construction market in the near past, large enough to develop such competent contracting agencies.

5.4.10 Adequate Experienced Construction Manpower (Technical and Managerial)

Due to thrust on short term targets, practically there was no development in hydropower sector barring the CPSUs during eighties and nineties, due to which the entire generation of engineers in this sector has gone without work experience and now when work has picked up, suitably experienced technical and managerial manpower at senior level is not available adequately and there is much poaching of manpower at senior level.

6. 7M Model

The 7M model is well knit structure, which would ensure timely and successful completion of Hydro electrical project involving various aspects on technical, financial, infrastructure and policy matters. It can definitely play a lead role for seating up of blue print towards accelerated harnessing of hydropower potential and make up the loss occurred so far. To summarize the role of every “M” is being indicated in succeeding paragraphs.

6.1 Master Planning/ Project Planning

The First foremost “M” of 7 M model “Master Planning “specifically focuses Planning issues covering Technical, Infrastructural, Financial and Policy aspects of the Model. More specifically, Model envisages the following under Master Planning/ Project Planning:

- Reliable, Realistic and Bankable Detailed Project Report
- Squeezing gestation period between DPR stage and Tendering Stage (including award of work) by accelerating start of pre-construction activities
- Resolution of inter-state disputes within the DPR stage only
- Set up single window clearance for hydro projects within six months of the submission of proposal.
- Selection of Project Developer i.e. Private Developer or Government Agency as applicable.
- Capacity building for development of competent indigenous Agencies and Manpower including technical knowledge development
- Address to Clear and community oriented R & R policy

6.2 Money

The second “M” i.e. “Money” is a fluid in which others “M”s are supposed to swim and act as a facilitator. It focuses on the following:

- Creation of Special-purpose funding vehicle, “Corpus Fund”
- Investment attracting concession agreements to attract big private players in hydropower development
- A clear road map for encouragement of Public private partnership (PPP)

- Exclusion of cost of access roads from project cost, as development of hydro projects triggers economic and commercial activities around the project site and results in economic benefit to the State
- Cost of security may be borne by the State/Centre in troubled areas and infested by militancy and terrorist activities
- Exemption of royalty on construction material, since the hydroelectric projects provide 12% free power to State
- Relaxation in custom duty for imported equipment and machinery for Mega projects.

6.3 Manpower

The third "M" i.e. "Manpower" is truly responsible for transforming the plans into action for speedier and quality construction. Adequate manpower equipped with the latest knowhow and technology from project management level to grass root level determines the fate of implementation of activities as envisaged.

6.4 Machinery / Material

The fourth "M" i.e. "Machinery / Material" implies the placement of "Right machinery at right place". Rightful selection of state of art equipment which would suit the construction methodology capable of executing an activity within the stipulated time frame governs the implementation in an intended manner. To quote, about 80m excavation below river bed under upstream coffer dam of Punatsangchhu-I hydroelectric project for arresting seepage in the construction pit of Main dam can only be handled with the latest state of art technology machinery i.e. rock cutters mounted on giant cranes by constructing plastic concrete Cut- Off-Wall.

Photo 1: Use of Latest Art of Technology

The status of equipment i.e. its age / usage is also an important factor which determines the efficiency of execution of an activity therefore the supply of brand new equipment adequate for mobilization, by the developer on the behalf of the contracting agency prior to award of works can resolve this issue to reasonable extent.

The fourth 'M' further emphasizes on the detailed planning and identification of the availability of construction material prior to construction and supply of the construction material to contracting agency

6.5 Moment

The fifth "M" i.e. "Manpower" is truly responsible for transforming the plans into action for speedier and quality construction adequate manpower equipped with the latest knowhow and technology. It focuses on the pre-construction activities to be completed prior to award of works and construction of roads and bridges may be constructed and paved by the Project Developer prior to inviting tenders and start of main civil works.

Photo 2: Construction of Road, Bridges and Contractor facilities

6.6 Monitoring

The sixth “M” i.e. “Monitoring” is truly responsible for squeezing Construction time with appropriate Construction Management technique and Construction Technology. The continuous monitoring of all activities pertaining to planning, design and construction are required for meeting the scheduled target on day to day basis.

Photo 3: Continuous Monitoring

6.7 Mid - course correction

The seventh “M” i.e. “Mid - course correction” is truly responsible for the following:

- Review of project implementation responsive to geological surprises, without a moment’s hesitation
- The availability of alternatives in respect of design and technology during the construction stage may serve as additional tool for mid course correction
- Project Optimization based on Concurrent Geological findings

To illustrate the 7 M principle is being applied during the finalization of Power House location of Punatsangchhu-I H.E Project in the complex heterogeneous geology.

The alternate locations are being shown in the Figure - 7, 8 & 9 as below:

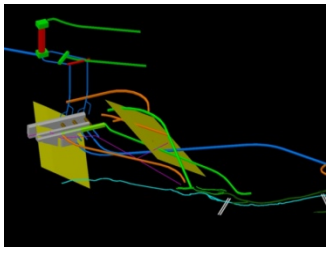

Figure 7: Alternative Powerhouse Location - 2

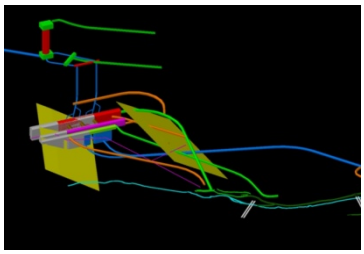

Figure 8: Alternative Powerhouse Location – 2 & 3

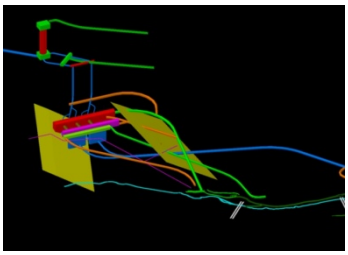

Figure 9: Alternative Powerhouse Location –3

Figure 10: Final Location Vis-À-Vis Shear Zone

The final location of Major caverns i.e. Powerhouse/ transformer hall/downstream surge caverns are suitably located on the basis of optimized geological findings and geotechnical investigations revealing the two shear zones in the vicinity of the structures, even during the construction of main components i.e MAT, CAT and other access tunnel.

7. Conclusion

The principles of 7 M model in accelerating the hydropower development, which integrates the best of innovative practices in construction and design aspects, could be used as a role model, as a whole. There is urgent need of a comprehensive policy framework on active implementation of 7 M Model for tapping hydropower resources. This model is time tested which reflects a success story in execution and commissioning of Mega hydroelectric projects i.e. Tala hydroelectric project (1020 MW). The Mega hydroelectric projects in pipeline i.e. Punatsangchhu-I (1200 MW) and Punatsangchhu-II (1020 MW) which are targeted to be completed as scheduled are following the similar principles of 7 M Model. It is the key to successful and accelerated execution of hydropower projects, wherein the innovations and mid-course corrections applied at various stages of construction and design aspects has made a substantial change. These innovative practices highlighted in paper in the form of “7M”

model, is surely the right path towards compensating for the time already lost towards achieving the goal for realisation of hydropower potential.

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