Hydro power projects of all sizes can result in net benefits to communities and the environment, provided they have a strategic fit in a river basin and are responsibly developed and operated.

A tailor-made solution is needed for Hydro Power Projects and Pumped Storage Projects in order to fit a given Topography, Geology and hydrology. A specific to site solution would often encounter difficult technical issues requiring resolving.

In order to handle such technical problems successfully and efficiently, newer technologies become mandatory to be adopted in the design and construction of the project. Hydropower Projects and Pumped Storages being River valley projects, involve civil works as a dominant part of implementation.

State of Technology in India in Civil Works of Hydropower:

To demonstrate methods followed under an Average Indian standard of handling problems as against International Standard, a broad comparison is drawn below:

S. No	International Standard	Average Indian Standard
1	Loose falls in surface and underground works - A rare phenomenon	A common phenomenon
2	Always embraces the technology appropriate to problem	Reluctance to embrace technology
3	Design & construction are specialization based	Design & construction are generalization based
4	Focus on planning followed by execution	Execution is managed somehow, without ensuring prior availability of necessary resources
5	Awareness level of client as well as contractor is high	Awareness level of client as well as contractor is not so high

Mr. S. K. Aggarwal, formerly a General Manager of NHPC having 5 nos. of Projects to completion and commissioning while in NHPC and thereafter completion and commissioning of Teesta III Project as MD of the Project was aware of the above shortcomings in Indian working methods. Each of the above shortcomings was addressed during Design and Construction of Teesta III. Not a single rockfall took place in 35 Kms of tunneling activity or in any of the slope cuts. So much so, the Project experienced an earthquake of a magnitude of 6.9 on Richter scale but no damage took place to any engineered excavation. However, large damages occurred to the un-engineered structures like roads and their associated rock slopes.

It was recognized that Geology plays a major part in construction of underground works and slope cuts. As this is the situation in every international project too, the question was how they succeed while we fail. It was known that in poor rock masses failure occurs ahead of the face during excavation, where the excavation has not yet reached. It was decided that the Geology should be sufficiently upgraded ahead of the face prior to the excavation even reaching there. Supporting the inaccessible L- Section of the tunnel ahead of the face was of prime importance, while supporting the X-Section behind the face was easier as it would be visible and accessible.

Moreover, this section already is partially supported by the strengthened face wall of the advance core.

As it is known that any collapse or rock fall makes the men and equipment vulnerable and causes delays, to be able to support the rock mass ahead of the face, pre-injection grouting was decided to be implemented. It is also known that Class of rock improves by at least one class by pre-injection grouting while in poor rocks improves by two classes (Barton). Moreover, the geological classifications are generally done in percentage of tunnel length basis and not chainage wise. It eventually gets left to the Civil Engineer at the face to decide the support class to be chosen from the drawings, who doesn't have the knowledge of Rock Mechanics.

Alternatively, it is left to a Geologist, who knows geology but his engineering skills about the interaction of rock and supports get stretched. Pre-grouting eliminates, or reduces the chances of a rock collapse including costly schedule delays. As on the spot decision of what lies ahead of the face at times may not be accurate, it was decided to implement probe drilling and pre-excavation grouting all along the tunnel to be absolutely safe.

Also, as civil engineers experienced in tunneling tend to make decisions about grouting also of which they know little, such engineers were given other responsibilities and "just-out-of-college" fresh engineers were quickly trained in what was required and given the responsibility of Pre-Grouting with powers to stop contractor's work, if the grouting was not done as intended.

Pre-Grouting is grouting of the rock mass which is yet to be excavated. It can be done from the tunnel face into the advance core or from the surface, if the tunnel is shallow. The consistency and strength of grout and the injection pressures were so chosen that the rock joints were fully packed and sealed in hard rocks. In case of weak but impermeable rocks, the pressures chosen were such that they would destroy the fabric of the rock and intrude into the fractures created, improving the strength of the overall rock mass.

Pressures of the order of 30 bars for grouting were used initially. However, for weak reaches grouting at 75 bars to 100 bars were routinely done with such increase in rock mass strength that advance core is safely excavated.

Initially, advance core of only above the spring line was deep probed by three drill holes and then grouted through five drill holes upto 15 m ahead of the face that too above the spring line. Over break above the spring line got limited to 2% because of such advance grouting, whereas below the spring line the over break was more than 7%. Seeing this data, it was decided to pre-grout the full circle of the face, including side walls and invert also. This increased the strength of rock mass as well as reduced seepage.

It was felt that rock strength, once sufficiently improved; the need for concrete lining shall get obviated. As the concrete lining was part of the tunnel as design lining, it was provided though its need was not felt. The thickness of lining was reduced from the design thickness and cross-sectional area of the tunnel got increased reducing the head losses in the tunnel from the 41 m theoretically computed to 30 m in field, which is a perpetual gain in electricity generation.

The tunnel is in service for the last 5 years with no observation.

To know more about the project http://teestaurja.com/about-project/