INVESTIGATING THE ILC SINGLE TUNNEL PROPOSAL IN A JAPANESE MOUNTAINOUS SITE

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Abstract

A design suited for a Japanese mountainous site for the conventional facilities of the ILC is proposed. In accord with the basic design concept of the Global Design Effort (GDE), all active accelerator components such as RF sources and cryomodules are installed in a single main tunnel. In addition we propose a multipurpose sub-tunnel: initially serving as a pilot tunnel for geological survey, then for underground water drainage during the construction phase, and finally during the operational phase the sub-tunnel can be also used for cooling water piping, underground water drainage, and as an escape tunnel.

INTRODUCTION

The sample site for the ILC in Japan is chosen to be located in a typical region of granite rock. The surface topography would be mountainous and inhabited. In places the ILC would be beneath several hundred meters of mountain such as shown in Fig. 1. While most of the surface above would be primarily naturally occurring mountain forests, we must also assume that in places there would be pre-existing extensive land use for farm and pasture, as well as human habitation, therefore the impact on the surface environment must be taken into careful consideration. Accordingly, it would be desirable to avoid large-scale surface development, and to keep the surface facilities as compact and concentrated as possible.

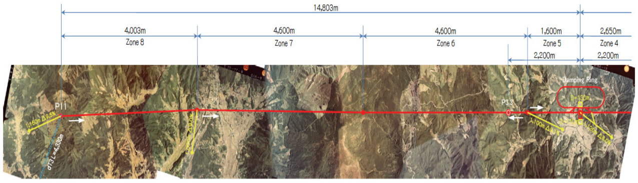

Figure 1: Tunnel layout in a mountainous site.

A Facility Working Group has been organized in the Technology Study Group of Advanced Accelerator Association Promoting Science and Technology [1] and it has put forth a proposal for a single accelerator tunnel (MLT, Main Linac Tunnel) with a parallel sub-tunnel optimal for a Japanese mountainous site. Figure 2 shows a conceptual drawing of what the overall facility layout might be and Fig. 3 shows a cross sectional view of this tunnel scheme. Cooling water piping with large bore size can be installed in the sub-tunnel. By using this high capacity piping infrastructure, long distance heat load transportation becomes practical and there would only have to be 3 above-ground cooling tower stations for the final heat load exchange into the air. Further, the design would be 'free' of the influence of the Japanese complex surface topography (hills, inhabited mountain sides, etc.). The sub-tunnel can also be used for an alternate emergency escape, and for underground water drainage, maintenance work and etc. This has many merits, among which are greatly reduced requirements on the surface environment and lessened difficulties in assuring personnel safety in an emergency.

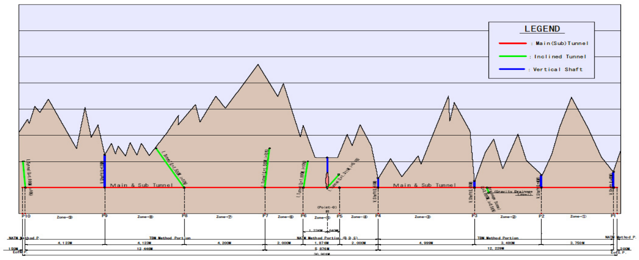

Figure 2: Overall facility layout (construction phase).

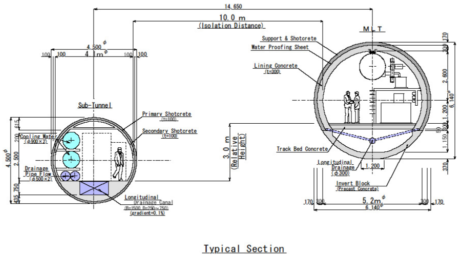

Figure 3: Tunnel spacing.

OVERALL FACILITY LAYOUT

The following three important criterion went into our consideration of elevation for the MLT, which in turn determines the rest of the design: (1) securing an earth cover of at least 100m at the location of the cavern containing the collision experimental hall, (2) securing an earth cover of at least twice the tunnel diameter (2D) in order to provide safety during tunnel excavation, and (3) securing an incline such as to permit natural gravity drainage discharge into nearby streams or rivers.

As for the conditions setting the distance separating the sub-tunnel from the MLT: (1) since the sub-tunnel construction proceeds the other tunneling, its location should facilitate drainage of the main tunnel, (2) in order

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to secure the safety of both tunnels, the associated sub-tunnel should be separated by a distance of at least 2D from the MLT, and (3) its location with respect to the MLT should be such that water can flow naturally to drain the MLT. Therefore, taking the above conditions into account, we have decided to fix the horizontal spacing between both tunnels at 10.0m between inside walls, and a vertical spacing of 3.0m as shown in Fig. 3.

SUB-TUNNEL

During the initial excavation and construction phase the sub-tunnel will function as a pilot tunnel facilitating the needed geologic technial survey before the main tunnel work. The access tunnels will be used during the construction phase for assembly and disassembly of the Tunnel Boring Machines (TBM), muck extraction, drainage and ventilation. After the completion of the civil engineering they will also be used for bringing in accelerator components as well as experiment equipment into the MLT. Fig. 4 shows a more detailed cross-sectional drawing of the sub-tunnel.

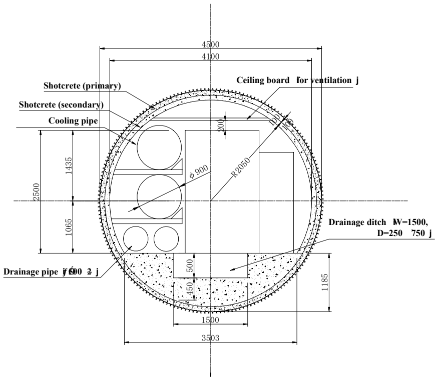

Figure 4: Proposed sub-tunnel cross-section.

MAIN LINAC TUNNEL

Beginning with the dimensions required for the facilities needed inside the tunnel as well as the space needed for operations, the actual target finished inner bore diameter is determined by the construction exigencies. Taking the current GDE guidance into account we have arrived at a finished inside diameter of Φ 5.2 m.

Linac Tunnel

We assume a uniform cross section for the main linac excavation regions. Assuming that a location with good geologic conditions can be chosen for the project, and further that the preceding sub-tunnel work has refined the geologic survey information and that we may expect that water drainage can be handled effectively then it should be appropriate to use a TBM for excavation, especially as that would shorten the construction time. Therefore the tunnel cross section should be circular. At the central region including the beam delivery system and collision point, Reference Design Report (RDR) drawings show that the circular cross section for the Linac section should transition between widths of 6.2m ～ 7.4m ～ 8.5m. Therefore because of its flexibility, we will use the *New Austrian* Tunneling Method (NATM) for the transition zones. Fig. 5 shows typical cross-sections for TBM and NATM excavations.

Almost Everything a Radiation Safety Control Region

The entire length of the MTL would be a radiation safety control zone. In particular, radiation shielding etc. would apply to the groundwater existing surrounding the tunnel. We assume a 30cm thick concrete lining and floor slab concrete as a countermeasure. Since we don't want any water to seep or leak into the tunnel, the entire tunnel including the floor slab should include a waterproofing membrane with a protective non-textile waterproof sheet.

Water Drainage Design

A representative design for the waterproofing and drainage construction is given in Figure 5. Particular features to be noted are: the entire length of the tunnel to be surrounded by a waterproofing membrane. Underground water getting to the tunnel arch would flow around the bonded non-woven fabric and impermeable sheet where it would be collected into perforated pipes running along the tunnel exterior. Therefore, there would not be water pressure on the outside walls of the tunnels due to water building up around them. Groundwater surrounding the tunnel will be drained away and led by transverse drain pipes to a large gauge central drainage pipe.

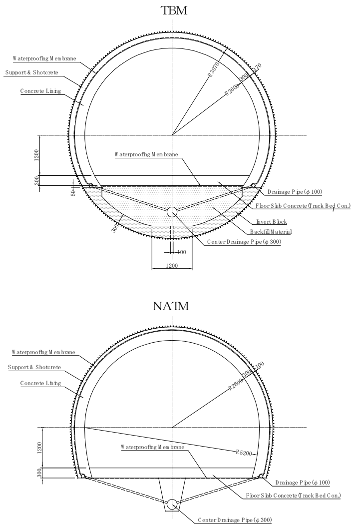

Figure 5: Typical MLT cross sectional drawings.

WATER INFLOW HANDLING

The quantity of water inflow that would result in a steady flow into the tunnel after completion depends on the particular site characteristics such as the geology, overburden characteristics, topography etc. However, using some hypothetical assumptions based on the newest comparative specific water inflow quantity data, we can estimate it to be about 1 ton/min/km. The water collected from each MLT zone would flow through the connecting passage into the sub-tunnel where it would join the drain water for that part of the sub-tunnel, this combined water would then be drained into the next sub-tunnel zone and finally drained outside through the main drainage tunnel (using natural discharge) as is shown in Fig. 6.

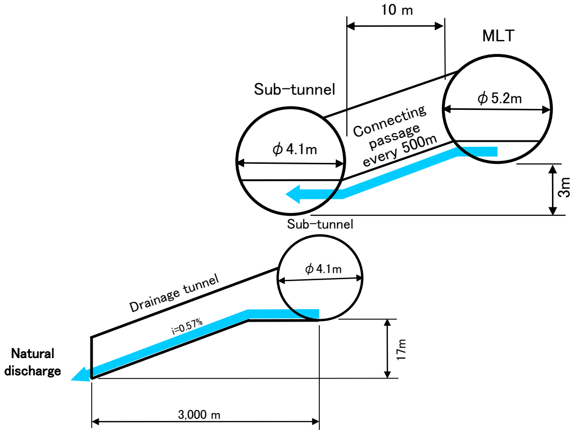

Figure 6: Design of water drainage.

EXPERIMENTAL HALL CAVERN

Because the collision experimental hall is in a very large cavern, careful consideration of the geologic structure is very important in the site determination. However, because its spot in the centre of the accelerator tunnel is fixed, in the event that the ground pressure conditions, directionality of the bedrock fractures etc. cannot be freely chosen, it may be necessary to go ahead with the cavern excavation not withstanding adverse conditions. At the very minimum there should be a ground cover of 2D or more. We assume the following conditions: (1) the bedrock under consideration is B ~ CH class granite (*Japan* Society of Engineering *Geology* classification), (2) the earth cover is on the order of 100m, (3) the cavern dimensions are 30m wide, 40m high and 120m long, (4) the shape is "bread loaf " (arch and vertical walls). A lining shall be installed after the excavation is complete. The design of the cavern and access tunnel support structures, construction methods and the project work order have been studied and the conclusion it that this plan would incur no serious risks.

PROJECT SCHEDULE

Based on the ground conditions, access and construction zones as shown in Fig. 2 for the sample site main linac tunnel, sub-tunnel and associated caverns, we made estimates for the access tunnel locations and numbers and scale. We suppose Zones (1)~(3) to be to going through a small overburden region and access would be by vertical shaft. Zones (4)~(6) are in the central region, it is planned that the excavation would be by NATM and access would be by inclined shaft such that each zone would be 2 km or less in length. Because Zones (8) and (9) of the sample site are under a surface topography where access is constrained, we assume locations for inclined shaft access tunnels at each end even though the zones become rather long and they would create the critical path for the project. Figure 7 shows our broad brush estimations of the scheduling for each zone. From the start of preparatory construction, the overall project would take approximately 5 years and 9 months. However, as the construction time of zone (2) is estimated to be shortest approximately at 3 years and 9 months in this scenario, parallel construction and facilities installation work would be possible for about 2 years.

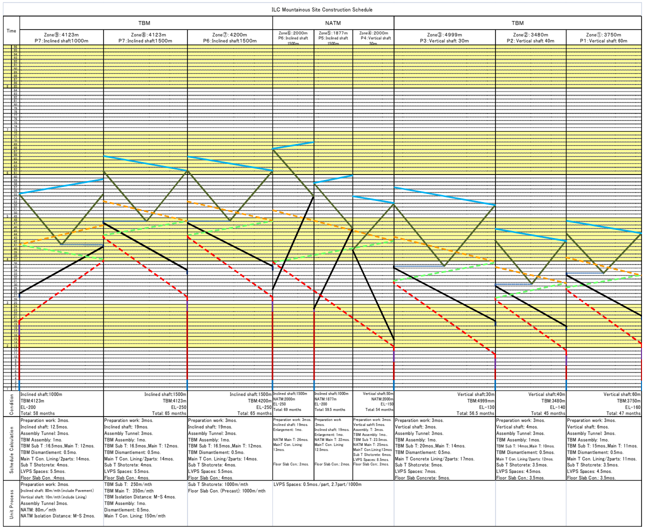

Figure 7: Project schedule.

ACKNOWLEDGMENT

This paper is based on the work of the members of the Facility Working Group, Technology Study Group, Advanced Accelerator Association Promoting Science and Technology. The author is especially grateful for the efforts by the following leading members of the working group: K. Fukuda (Shimizu Corporation), S. Shikama (Kumagai Gumi Co., Ltd.), I. Sekine (Toda Corporation), H. Sasao (Tekken Corporation), S. Ebisu (Okumura Corporation), M. Kuji (Maeda Corporation), K. Ryoke (Taisei Corporation), Y. Kawabata (Tobishima Corporation), K. Akiyoshi (Obayashi Corporation), K. Ishiyama (Nishimatsu Construction Co., Ltd.), T.Haruki (Takenaka Civil Engineering & Construction Co., Ltd.), T. Akoshima (Kajima Corporation), K. Kawakami (Penta-Ocean Construction Co.,Ltd.), T.Nishimura (Hazama Corporation). The author is also grateful for the help of the following KEK colleagues: A. Enomoto, M. Miyahara, K. Hosoyama and A. Yamamoto.

REFERENCES

[1] http://aaa-sentan.org/en/about_us.html