4.7 Development of engineering technology for deep underground

In Phase I-a, development of engineering technology was carried out for deep underground application. These are:

- Considered the basic concepts of the MIU Project design, including facilities and science program
- Determine investigation items to be carried out in and after Phase II by referring to domestic and overseas experience and Japanese requirements for an underground research laboratory set out by the Atomic Energy Commission (1994) [(1)]
- Conceptual design of the research gallery layout.

Regarding the development of the research galleries, the following must be taken into consideration.

① Unlike other underground civil structures, excavation is considered an integral part of the research and therefore, research activities are to be carried out during the excavation.

② Investigations are expected to follow a series of procedures: surveys → simulation → prediction → verification. In case unexpected geological environments are encountered, the facility design and the research plan should be flexible enough to cope with the unexpected geological environments by either avoiding them or incorporating them into the study objectives. This is "Design As You Go" and is considered necessary to ensure excellent results [(101)].

Geoscientific research carried out in the MIU Project consists of:

① geological investigations
② hydrogeological investigations
③ hydrochemical investigations
④ solute transport
⑤ rock mechanical investigations
⑥ investigation techniques and equipment
⑦ engineering technology for deep underground
⑧ seismological observations, etc.

These investigations are complexly inter-related. Therefore, it was considered important to design an appropriate layout that will allow achieving the goals of the entire project and of each Phase. In designing the layout, the interrelationships of the experimental activities, their requirements in terms of location, access, duration etc must be taken into consideration.

Basic concepts of designs are examined from the above-points of view. In addition, domestic and international experience and Japanese government requirements for underground research laboratories outlined by the Atomic Energy Commission (1994) [(1)] are examined and investigation items to be carried out in Phases II and III determined [(102)].

4.7.1 Basic design concept

Basic design concept considered in Phase I-a was as follows (Figure 4.81).

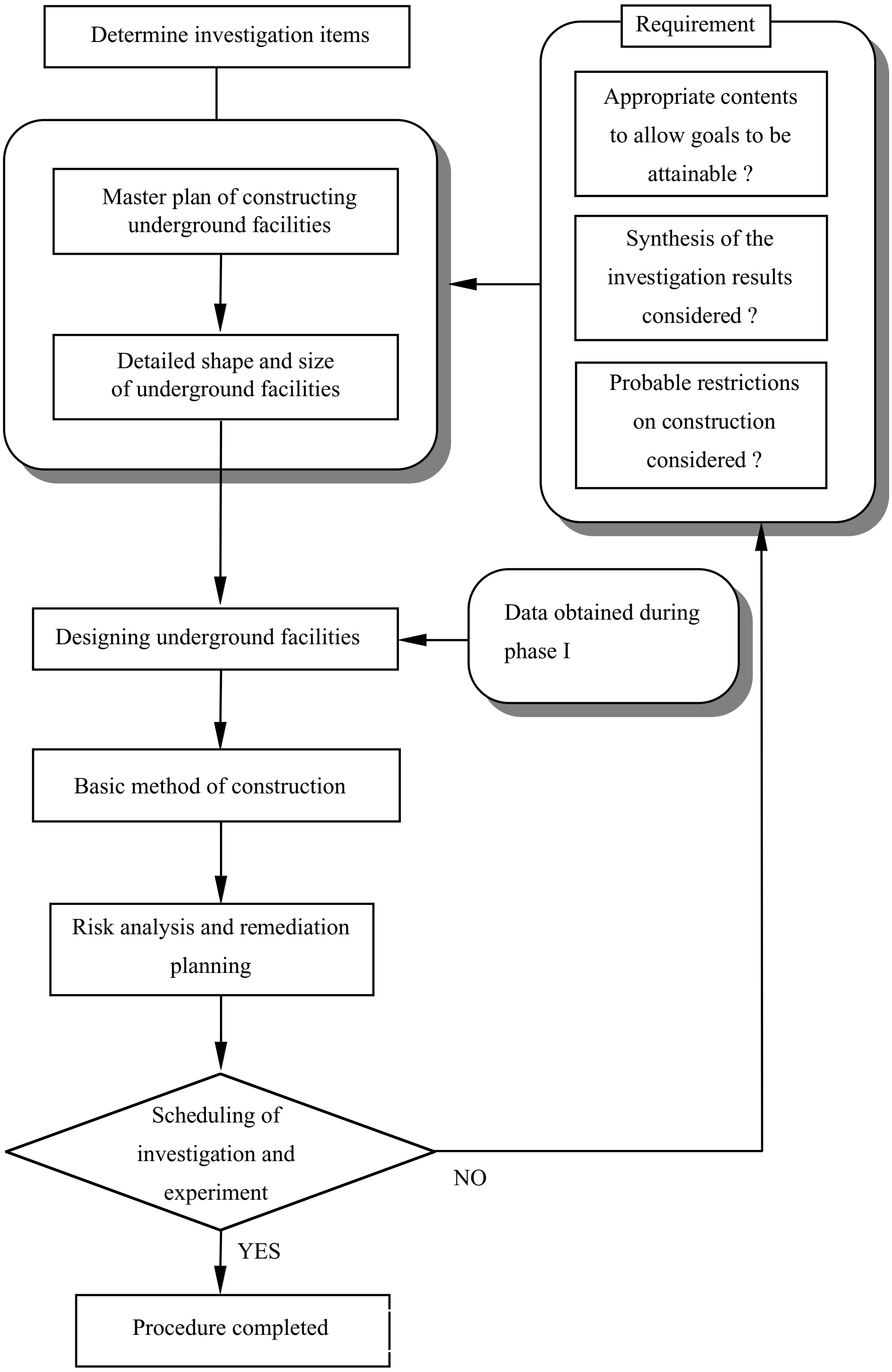

Figure 4.81 Procedure making for overall construction and investigations

First, based on the expected geological conditions in the MIU Project, a range of investigation items is considered. Next, the Master Plan was developed for constructing the underground and surface facilities. Also, detailed size and shape of the facilities were examined. Requirements for these examinations for design of facilities are as follows.

- Investigation items to allow the goals of Phase I to be attainable.
- Synthesis of the investigation results are taken into consideration.
- Probable restrictions on construction are taken into consideration.

Based on the data obtained in the Phase I and the investigation items, the layout of the research galleries takes concrete shape.

Details of the above three requirements are as follows.

<u>Investigation items allow the goals of Phase I to be attainable</u>

This requirement should take the following into consideration.

- Conditions of the geological environment needed for individual investigations

  For example, fracture (zones) serving as water paths and intersections between faults and research galleries are necessary for investigations in and after the Phase II. A major consideration is the hydrogeological flow system. For example any activities at the stages that would impact on hydraulic conditions should be done down gradient of any hydrogeological or tracer test experiments. Location relative to boundary conditions should also be considered.

- The repetition of individual investigations

  The predictions made in Phase I and the investigation methodologies can be re-evaluated by repeating the same experiment or study at both the Middle Stage at 500 m depth and the Main Stage at 1,000 m depth. For depth-dependent investigations, repetition of experiments or studies will be done at as many depths as possible using the above Stages or the Spare Stages. Spare Stages (horizontal, horse-shoe shaped, 3 m×3 m) are to be constructed approximately every 100 m depth, for experiments and studies and to install drainage equipment for maintenance of the research galleries. If unexpected geological are encountered the investigations, with possible reiterations, will be decided in the future.

- Period required for individual investigations

  Approximate schedules and durations must be set properly.

<u>Synthesis of the investigation results are taken into consideration</u>

With the purpose of establishing comprehensive investigation techniques for geological environments, it is important to synthesize the data from various investigations. It is important to construct comprehensive methodologies of "geosynthesis" for a variety of reasons, not least of which is to ensure appropriate and sufficient data is collected for integrated model building and for all concerned end users. For this requirement, objectives for individual investigations (e.g. fractures, fracture zones, faults, etc.), target areas, experiment siting and schedules for performance must be taken into consideration.

Probable restrictions on construction are taken into consideration

It is important to specify various conditions related to the construction schedule, method and facilities required for the investigations. Research galleries will be constructed throughout Phases II and III. Investigations in both Phases will be carried out simultaneously with the related construction work such as excavation and drilling. Therefore, the scheduling of research and construction activities and the timetable exert a great influence on the whole project. Construction itself might need to be suspended so as to perform high priority research investigations, if possible, without having an adverse effect on the overall project. For example when galleries are expected to intersect large or significant fracture zones or faults or when unexpected geological conditions are encountered.

4.7.2 Example of layout of underground facilities

Domestic and overseas experience and the requirements for underground research laboratories outlined by the Atomic Energy Commission (1994) [1] were examined. This exercise is useful in the preliminary planning or scoping of research activities that might be performed during and after Phase II. Complementary to this activity, the conceptual layout of the research galleries was examined. However, investigation activities and facility plans are not finalized yet. They will need to be further developed as the investigations in Phase I progress.

A conceptual layout of the underground facilities is as follows.

The MIU consists of surface facilities, the Main and Ventilation Shafts (each 1,000 m depth), the Main Shaft with a spiral ramp and two principal research locations where most galleries will be excavated, the Middle and Main Stages, for investigations in Phase III. The spiral ramp was designed to avoid premature disturbance of the Tsukiyoshi Fault due to intersection by the Main Shaft at about 950 m depth. The current layout is shown in Figure 4.82.

The Shobasama Site is underlain by rock that has variable structural styles; an uppermost deeply weather zone (～15m deep), a highly fractured 400 m thick structural domain immediately below the weathered rock, a 300 m thick structural domain from about 400 to 700 m depth with a fracture density lower than the rest of the granite. The deepest structural domain, deeper than 800 m, has the highest fracture density. This domain (fracture zone) is considered to be related to deformation due to fault movement. To ensure investigations are done in all the variety of geological settings possible, research galleries are planned at around 500 m and 1,000 m depth. Also, the spiral ramp is constructed to avoid the fault for scientific and operational reasons. One operational reason is to avoid potentially large water inflows from the fracture zones associated with the Tsukiyoshi Fault into the Main Shaft. A scientific reason is to avoid disturbance of the hydrogeological flow field associated with the fault before it can be properly instrumented and studied by boreholes and possibly by Mine-by type experiments. In addition, an operational advantage can be expected for the transportation of construction machinery and drilling of horizontal observation boreholes at several depths can be done more easily.

The surface facilities are composed of research/administration facilities, a sample storage area, an equipment maintenance facility, a shaft head-frame facility, a muck deposit and a wastewater treatment facility.

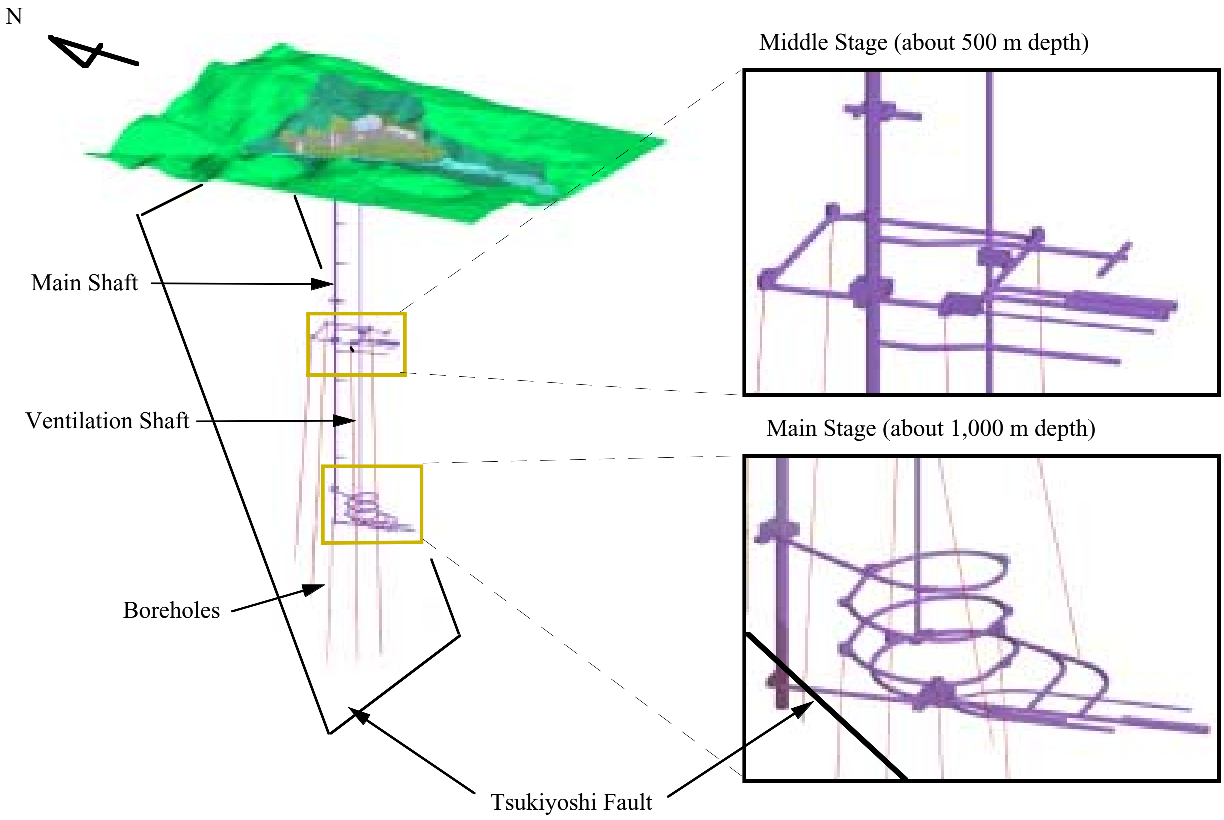

Figure 4.82 MIU conceptual design