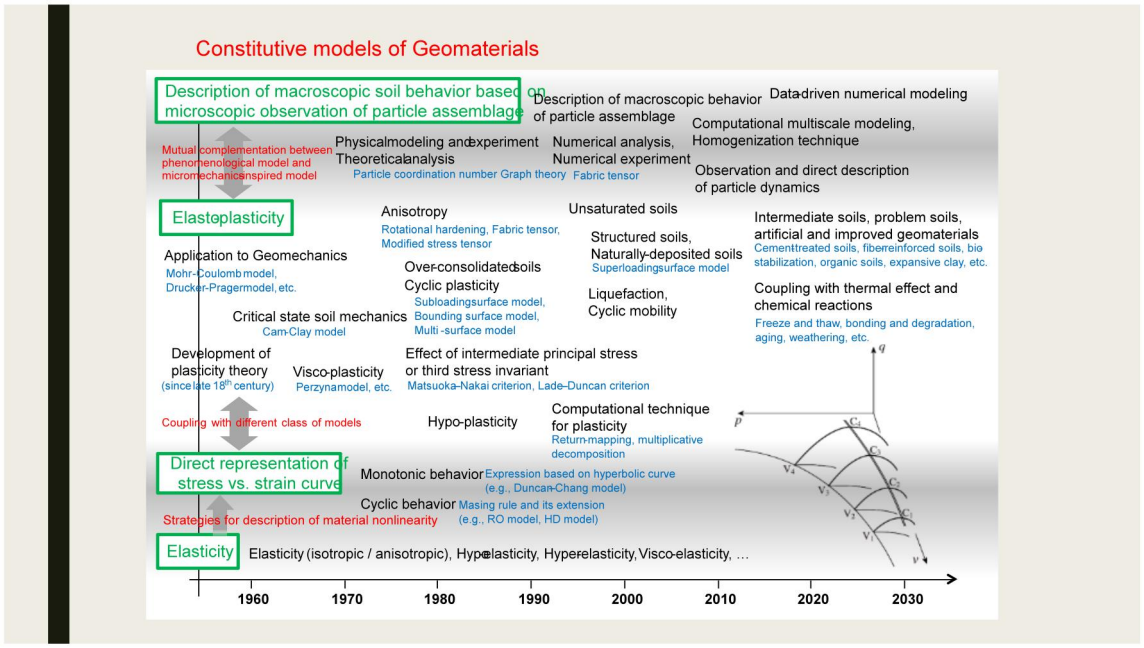
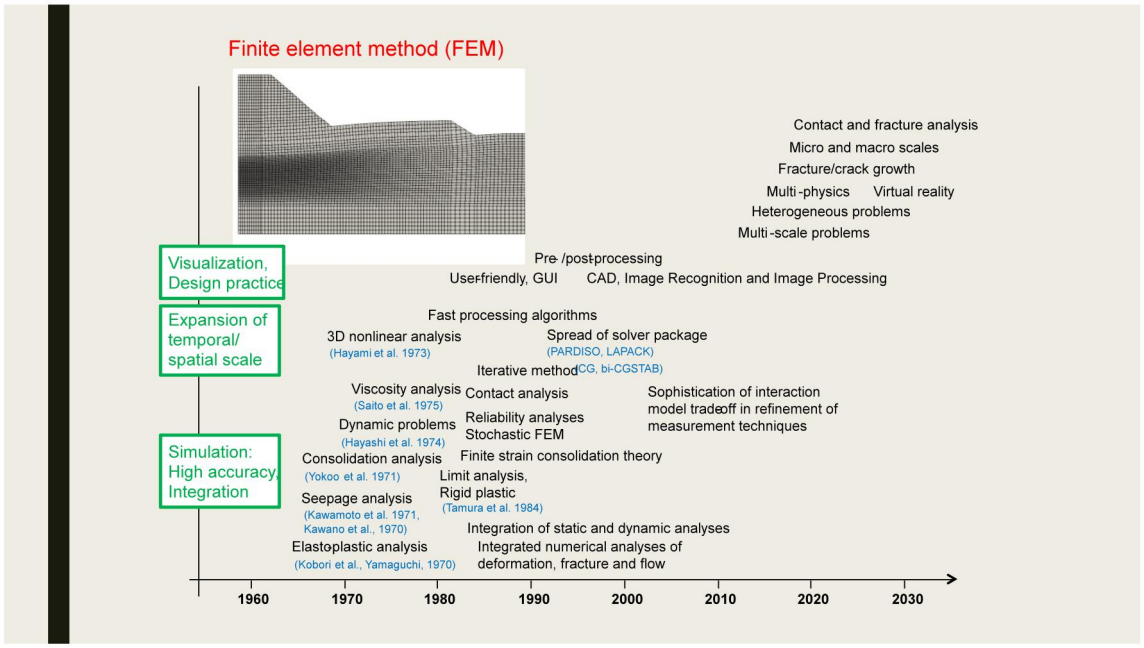
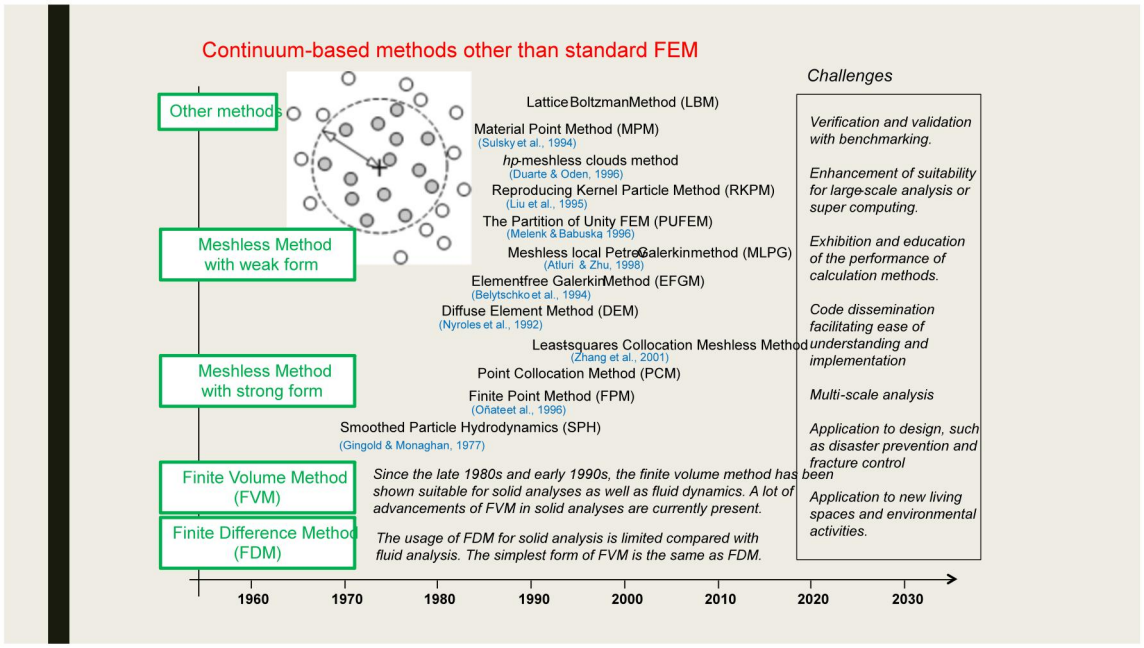
We have prepared “academic roadmap” as a product for the time capsule project. There are 5 slides which summarize specific subjects, such as “Constitutive model”, “FEM”, “Non-FEM”, “Discrete modeling” and “Application”.



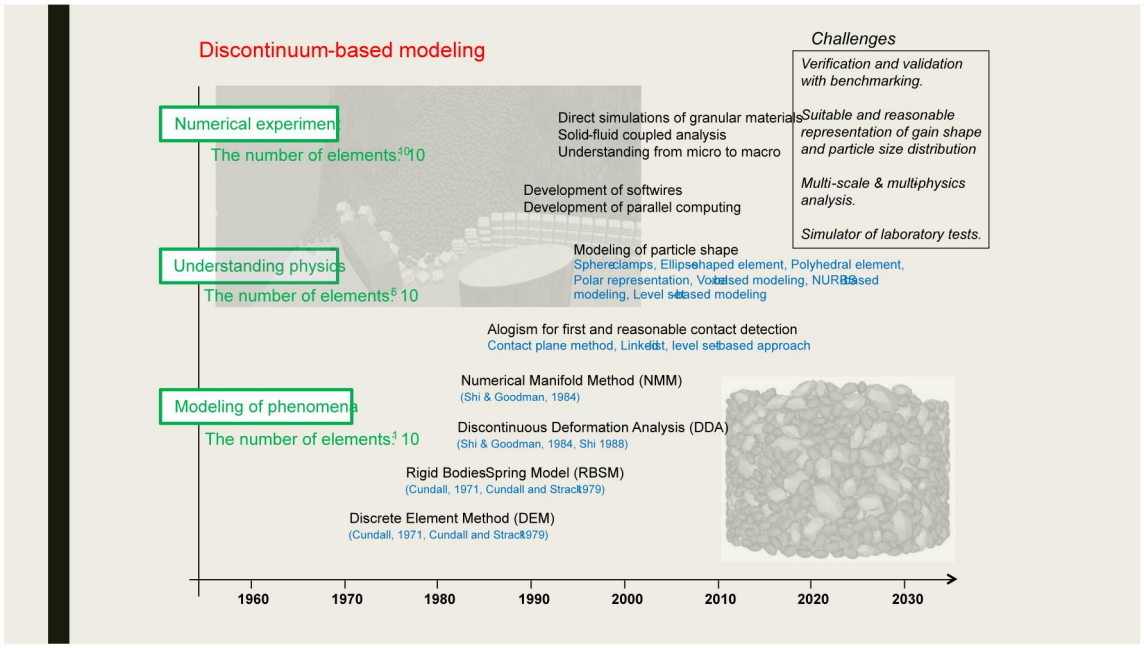
The first slide of the academic roadmap is related to “constitutive model”. The horizontal axis means decades of time. The vertical axis shows categories and usually it implies the development of the subject. Keywords and important steps are put in the figure with the time and the categories. The blue phrases mean supplementary information, such as references. For example, the vertical axis starts with “Elasticity” and “Direct representation of stress-strain relationship”. When we go up along the vertical axis, there is “Elasto-Plasticity” and “Macroscopic modeling based on microscopic observation or computation”. In the main figure, we can look at a number of keywords, such as cyclic behavior, visco-plasticity, anisotropy, liquefaction, unsaturated soils, and so on. The top and right part of the figure, we can know some keywords for future tasks or challenges.



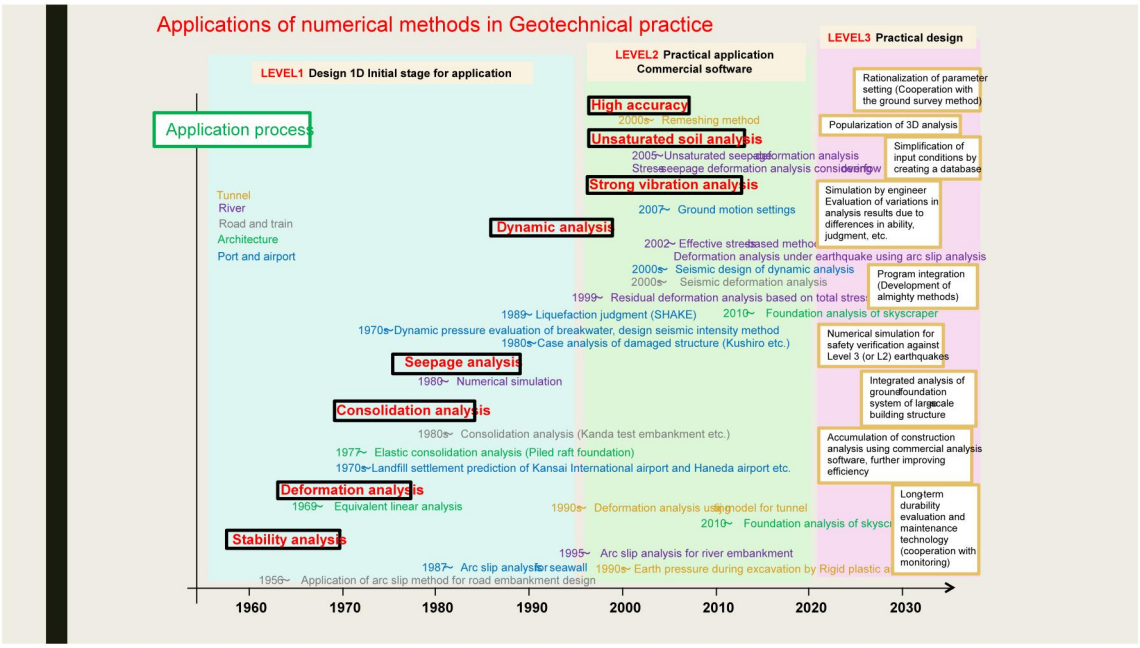
The second sild is related only to FEM, which has been the most popular numerical method in geotechnical engineering. FEM has been used for accurate prediction of soil behavior, even if it is sometimes fundamental and sometime complex. Due to the development of computers, the scales of the computation expanded in space and time, and FEM is also used for design of structures in practice. You can find keywords, such as seepage analysis, dynamic problems, reliability analysis and so on. In the top and right part, we can also check some challenges, such as multi-physics and macro-micro scales.



This (next) slide was made for continuum-based methods other than FEM shown in the previous slide. There are finite difference method (FDM), finite volume method (FVM), Meshless methods with strong and weak form, and other methods, as shown in the vertical axis. FVM for solid analysis is still under development, while several meshless schemes were proposed in 1990s. We also included material point method (MPM) and lattice Boltzmann method (LBM) as other methods. Challenges for future woks are written in the right side.



The side shows the history and development of discontinuum-based modeling. The vertical axis simply means the increase of the number of elements or particle. The discontinuum-based modeling started with discrete element method (DEM) and there are also some important methods, such as DDA and NMM. The challenges for this subject can be seen in the top and right side.

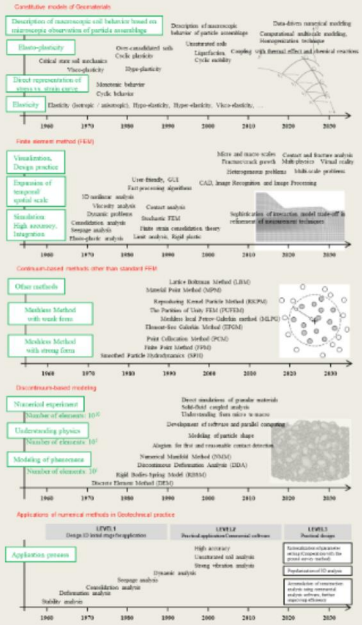


The final slide of the academic roadmap is related to application of numerical method in geotechnical practice, which is also an important topic for TC103. The vertical axis just means application process. The application to the types of structures, such as tunnel, river, road & train, architecture, port & airport, are written in different colors. You can look at the application to conventional stability analysis, consolidation analysis, seepage analysis in the level 1 column, and there are strong vibration analysis and unsaturated soil analysis in the level 2 column. In the level 3 column, we can know current or future tasks regarding numerical methods for practical design.

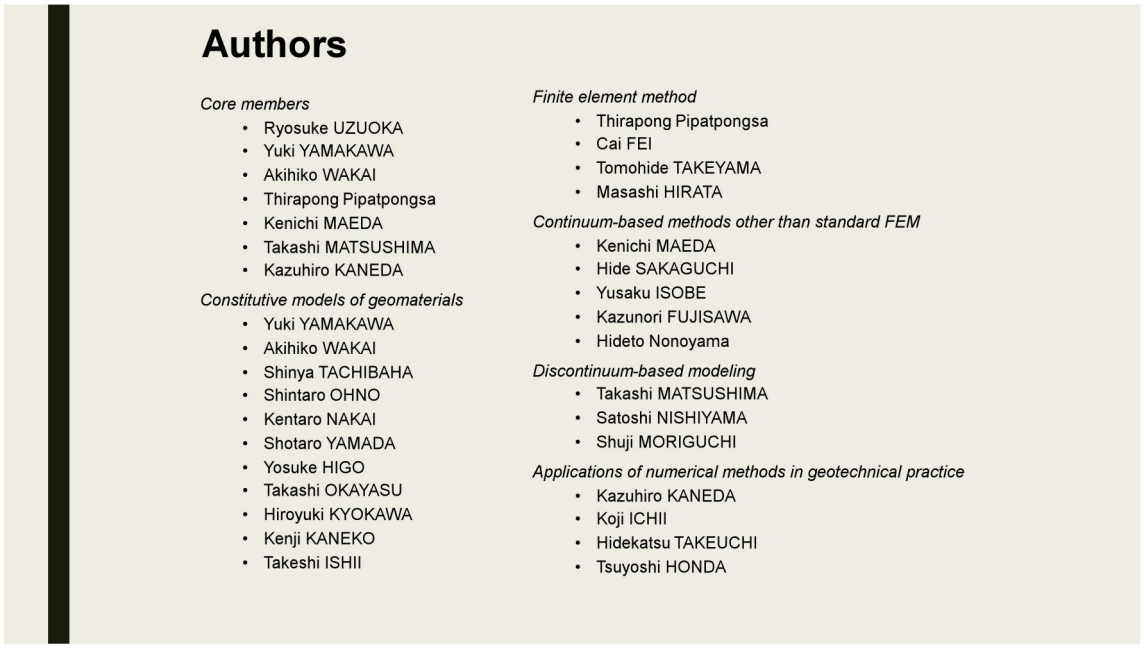
Summary of academic roadmap

Summary of academic roadmap (One page article) is available at the following link.

https://drive.google.com/file/d/1yaTZ9BJgtl_EEr s5qCrqL8lVRjwH0nnR/view?usp=sharing



We have summarized the above-mentioned 5 slides into a one-page article, as illustrated in the right side of this slide. We can look at more concise 5 slides in one page, which is available at the link.



Finally, we would like to show the list of the authors of the academic roadmap. Precisely speaking, the original academic roadmap was made several years ago for another project of Japanese Geotechnical Society (JGS). The local Japanese committee of TC103 has revised it for this time capsule project. The revised slides are the ones shown here. Hence, the authors of the original academic roadmap are included in this list.