Subcommittie 345

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The Subcommittee for the Study of Chemical Interactions between Cement-based Structures and the Surrounding Ground (345 Committee) explored the possibility of an integrated assessment that considers the chemical interactions at the interface between cement-based structures, such as concrete structures and cement improved bodies, and the surrounding ground. The study focused on the boundary domain between concrete engineering and geotechnical engineering. The purpose of the study was to identify engineering issues and develop new academic fields through cross-disciplinary efforts, rather than traditional field-by-field research. Fifty-five members engaged in research for two years from October 2011.

The research was conducted by different working groups: The Solidification and Insolubilization WG (WG1), the Chemical Erosion WG (WG2), and the Super-long-Term Durability WG (WG3). Figure 1 shows the committee’s research range and each WG’s items of study.

WG1 studied the chemical interaction between cement-improved soil and the surrounding ground and also between a cement-hardened body in cement-improved soil and the soil particles that are the base material. The study chiefly investigated the long-term stability.

WG2 studied the interaction between underground concrete structures and the surrounding ground. The study focused on the severe conditions in which sulfate, acid, and other materials present in ground act on concrete.

WG3 also studied the chemical action between underground concrete structures and the surrounding ground, but the word group targeted radioactive waste disposal facilities that require super-long-term stability. The study primarily investigated chemical interactions as a mutual action between cement-based materials and bentonite, both of which have potential for use in artificial barriers. The interaction with the surrounding ground, which serves as a natural barrier, also was discussed.

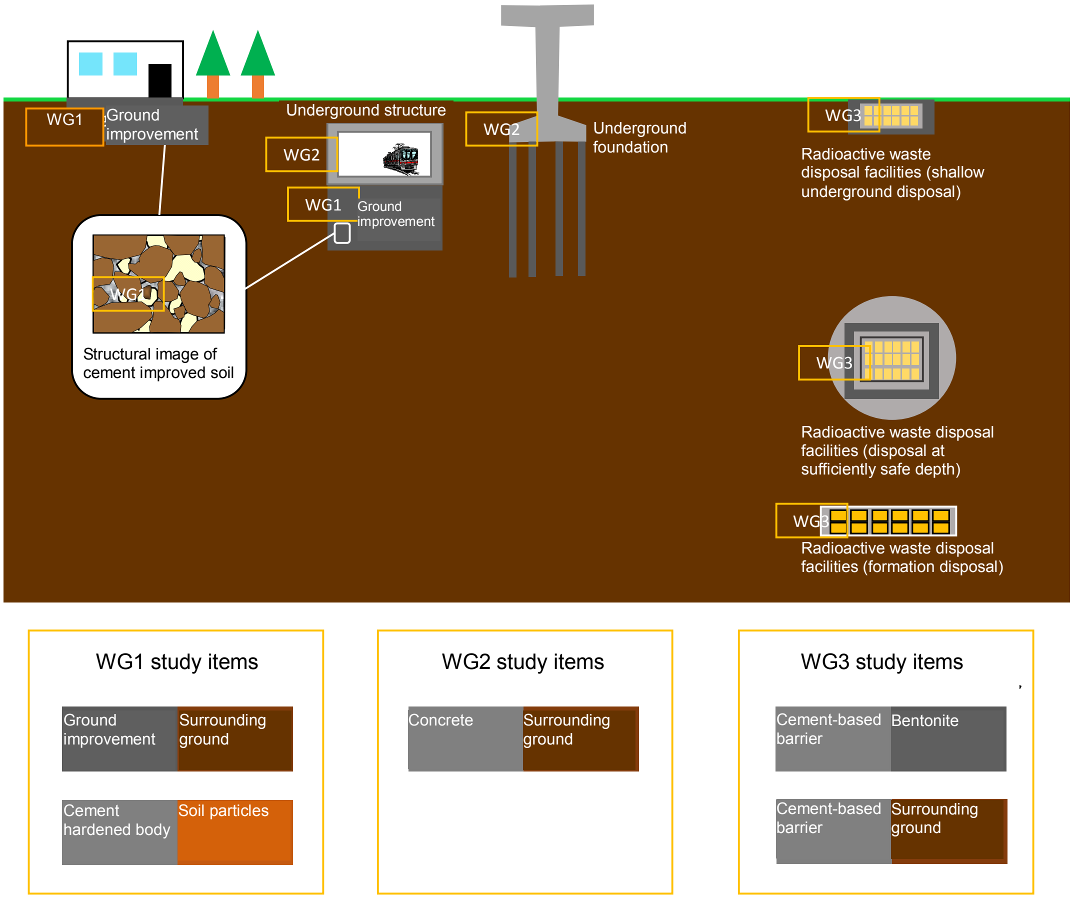

Figure 1. Range of the committee's research and items studied by each WG

The WGs' activities are summarized below:

1. WG 1: Solidification and insolubilization WG

   Chief researcher: Kenichiro Nakarai, Hiroshima University; Secretary: Toru Inui, Kyoto University; 19 committee members

   To assess the long-term durability of cement-based materials, the nature of which lies between concrete and ground material, WG1 analyzed the strength of cement-improved soil the insolubilization of heavy metal, and the mass transfer resistance. The long-term stability and durability of these cement-based materials were then investigated. Issues were identified by conducting interviews with researchers. The mechanism was analyzed by comparing the concrete materials described in the literature. The new knowledge was then systematically organized.

2. WG2: Chemical erosion WG

   Chief researcher: Yoshifumi Hosokawa, Taiheiyo Cement Corporation; Secretary: Tsuyoshi Saito, Niigata University; 22 committee members

   To assess the durability of concrete structures subjected to the chemical action of the surrounding ground, WG2 studied the deterioration of concrete structures by the actions of acid and sulfate (Part 1). Cases of deterioration at home and abroad were collated. The current knowledge about deterioration phenomena, deterioration prevention measures, etc., was systematically organized.

3. WG3: Super-long-term durability WG

Chief researcher: Isao Kurashige, Central Research Institute of Electric Power Industry; Secretary: Kazuko Haga, Taiheiyo Consultant Co., Ltd.; 22 committee members

The group assessed the durability of concrete structures subjected to the chemical action of the surrounding ground (Part 2). In regards to the chemical interaction between a clay-based material (bentonite) and a cement-based material (mortar and concrete), which are used for artificial barriers at radioactive waste disposal facilities, the needs regarding academic study and the current knowledge of the phenomena were collated. Information regarding experimental techniques and analysis codes to assess super-long-term durability was organized.

Table 1 lists the studied chemical interactions, etc., between cement-based materials and ground materials. The study range for each WG was as broad as possible and included the relevant items for each study. The table reveals that while materials and structures vary considerably with each WG, some items relate to all the WGs, such as eluviations and chemical erosion, which are related to the dissolution of hydrates. Here, in addition to the dissolution of hydrates, physical and chemical events, such as the transfer of ions in pore water and the generation of secondary minerals, can become subjects of assessments of analysis codes that modeled and integrated both mass transfer and chemical actions. Numerous analysis cases are already available, such as WG2's study of the deterioration of general underground concrete structures and WG3's study of the super-long-term stability of radioactive waste disposal facilities. The study cases of each group were presented and can be assessed in a common frame.

On the other hand, attention also should be paid to the differences in the spatial and time scales. For example, the cement-improved soil studied by WG1 contains a larger number of continuous coarse voids than the concrete studied by WG2 and WG3, which shows that their spatial scales in organizational structure differ greatly. Coarse voids accelerate mass transfer and also provide places that allow secondary minerals to precipitate. A change in solid-phase volume resulting from dissolution and precipitation can, therefore, have varying influences on various physical property values. Moreover, while WG2 and WG3 both targeted underground structures, the time scales differed considerably. There may have been various influences on the speed of chemical reactions, such as dissolution and precipitation.

Table 1. Chemical interactions and other items studied by the WGs

	Chemical interactions and other items
WG1	Carbonation, eluviations, chemical erosion, repetition of hydration and dehydration, freezing and thawing, alkali aggregate reaction, and thermal action
WG2	Chemical erosion, repetition of hydration and dehydration, and thermal action
WG3	Eluviation of cement hydrates, deterioration of bentonite by alkali action, and generation of secondary minerals at the interface

The investigation also directly applies to the development of cement-based materials and the construction of cement-based structures that are highly resistant to chemical interaction with the surrounding ground. One possible approach is the use of cement-based materials that are solid enough to curb mass transfer and stable enough under the assumed chemical actions in order to minimize chemical actions by the surrounding ground. At the same time, overall stability can be increased by enhancing the performance of substances created by the chemical interactions.

As described thus far, research has focused on the chemical interactions between cement-based structures and the surrounding ground and clarifying the mechanism. The results show that it is possible to predict the deterioration and long-term stability of cement-based materials and develop new materials. In the future, through further quantitative analysis and modeling of the chemical interaction mechanism and by other methods, the accuracy of predictions can be improved and efficient materials developed. We hope that cross-disciplinary research will accelerate and lead to new knowledge in the field of concrete engineering.