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ISO 19906 and Frozen-spoil/Permafrost Engineering

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Abstract

A study group on the International Standards for Arctic Offshore Structures (ISO 19906) and the frozen ground engineering started in April 2019 under the program of Hokkaido University Arctic Research Center.

The ISO 19906 has been developed by an ISO working group (WG8) and was published in 2010. An update of ISO 19906 was initiated in 2014 to incorporate new knowledge from offshore development projects, joint industry research projects, and address previous comments that were beyond the scope of the first edition. The ISO 19906 Second Edition was finally published in July 2019.

Through the last decades activities of the frozen-soil and permafrost engineering, it was confirmed that their technologies in Japan was somewhat outstanding in both engineering and scientific aspects. However, the decrease of projects in these engineering fields in the world resulted in discontinuity of technology succession among the engineers in Japan. The study group discussed how they inherit the frozen-soil/permafrost engineering technologies and proposed how to overcome this situation in Japan.

Key words: ISO 19906, arctic offshore structures, frozen soil, permafrost.

1. ISO 19906 Second Edition

1.1 Kick-off meeting in June 2014

The series of documents ISO 19900 to ISO 19906 addresses design requirements and assessments for all offshore structures used by the petroleum and natural gas industries worldwide. ISO 19906 is one of a series of documents and focuses on Arctic offshore structures.

Kick-off working group meeting to update ISO 19906 was held in Hamburg Germany on June 11-12, 2014 led by Canada. County members from thirteen countries participated the meeting from Canada, China, Finland, France, Germany, Japan, Kazakhstan, The Netherlands, Norway, Russia, Singapore, UK, and USA. Karen Muggeridge of ConocoPhillips Canada was appointed as new convener of WG8.

1.2 ISO 19906 and other ISOs

The relationships between ISO 19906 (2019) and other ISO Standards for offshore structures and arctic operations are shown in Fig. 1 (Muggeridge et al., 2019). ISO 19906 is incremental to the ISO 19900 series of standards dealing with offshore structures, prepared by ISO/TC 67/SC 7 (ISO 19900 to ISO 19906). It is complemented by the series of International Standards on arctic operations, prepared by ISO/TC 67/SC 8 (ISO 35101 to ISO 35106). While the arctic structure standard does not deal explicitly with mobile offshore drilling units (MODUs), its provisions are referenced in ISO 19905-1 and ISO 19905-3. ISO 19906 is also referenced for offshore wind turbines in ISO/FDIS 61400-3-1.

1.3 Structure of the ISO19906 (2019)

The first edition of the International Standard for Arctic Offshore Structures was published in December 2010 (ISO 19906, 2010). This standard, coordinated by Canada, was produced by Working Group 8 within subcommittee ISO/TC67/SC7 Offshore Structures.

The 2010 edition has been updated to reflect the latest developments in design to ensure safe and environmentally responsible design for operations in arctic, subarctic and temperate offshore regions where icebergs and sea ice are present. The clauses in ISO 19906 (2019) are listed in Table 1 (Muggeridge et al., 2019).

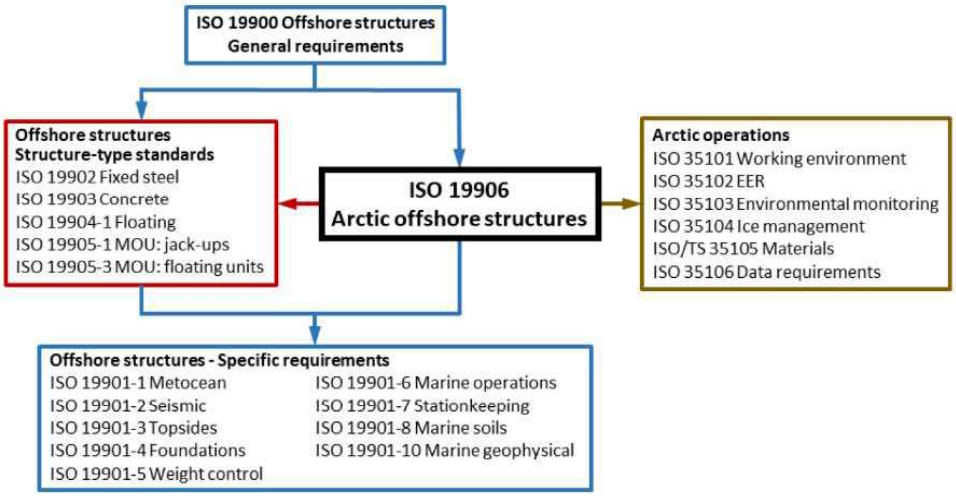

Fig. 1 ISO 19906 relationships to other offshore structures and arctic operations standards.

1.4 Recent Technical Papers on ISO 19906 (2019)

The papers listed below highlight some of the subject areas updated in ISO 19906 (2019) and published at the 25th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC2019), June 9-13, 2019, Delft, The Netherlands.

1) Muggeridge, K. J., R. F. McKenna and G. Thomas (2019): "ISO 19906: 2019 – an International Standard for Arctic Offshore Structures."

2) Thomas, G. and M. A. Maes (2019): "Design Situations and Limit State Verification for Arctic Offshore Structures."

3) Matskevitch, D. G. and G. Thomas (2019): "Ice events and ice actions in ISO 19906."

4) Eik, K. J. and G. Thomas (2019): "Low temperatures: terms and their application in ISO 19906."

5) Makrygiannis, C., O. Dalane, P. Liferov, R. McKenna, P. O. Moslet, K. Riska and B. Wright (2019): "A Philosophy to Ensure the Safety of Floating Structures in Arctic and Cold Regions."

6) Hendrikse, H. (2019): "Dynamic ice actions in the revision of ISO 19906."

7) Ralph, F. (2019): "ISO 19906 Updates: Global Local Ice Actions."

8) Besseling, F., A. Lengkeek, H. Waard and K. Nieuwenhuis (2019): Ice actions for hydraulic structures of primary flood defense Afsluitdijk - Applying ISO 19906 at home."

Table 1. List of clauses in the ISO19906 (2019)

Clause	Title
1	Introduction
2	Normative references
3	Terms and definitions
4	Symbols and abbreviated terms
5	General requirements and conditions
6	Physical environmental conditions
7	Reliability and limit states design
8	Events and actions
9	Foundation design
10	Man-made islands
11	Fixed steel structures
12	Fixed concrete structures
13	Floating systems
14	Subsea production systems
15	Topsides
16	Other ice engineering topics
17	Ice-specific operations
18	Emergency response
Annex A	Additional information and guidance
Annex B	Regional descriptions

2. Frozen-soil/Permafrost Engineering

The scientific researches on sea-ice and/or frozen soil and permafrost are available regardless of social demands. However, the R&D activities on sea-ice engineering and/or frozen soil and permafrost engineering are dispensable if there are no social demands. Under these situations there are no rooms for the young successors to learn engineering skills on these areas. Unfortunately, the situation above is happing in Japan now. As the result, our skillful and experienced technologies on these areas are facing pessimistic situations.

The research activities on sea-ice and/or frozen soil and permafrost in Japan had been high from 1940's. Dr. Ukichiroh Nakaya was the one of the predominant person on scientific and engineering activities in these areas in1940's. In the late 20 century, Professors Hiroshi Saeki and Seiichi Kinoshita of Hokkaido University have worked on sea ice engineering, and frozen soil and permafrost science, respectively. They have educated many students who have knowledge on sea ice engineering, and frozen soil and permafrost science.

These students have carried out R&D on design and construction methods of "artificial island for arctic oil and gas exploration and production" and "LNG in-ground storage tank" and established the leading technology in the world. It is noteworthy that the R&D activities mentioned above have been based on the social demands such as oil and gas production in arctic regions and LNG in-ground storage tank construction at the metropolitan area.

Regarding to the frozen soil engineering and permafrost engineering, a useful empirical formula was proposed by a

Japanese engineer who was the engineer of aerodynamics during the last war. The formula gives the soil frost heave ratio, which varies with the freezing conditions such as confining pressure and cooling conditions. The parameters of the formula are available by using a standard test method standardized by the Japanese Geotechnical Society.

By using the formula and the standard method, we have designed and constructed about one million cubic meters of artificially frozen soil in Japan. It is also noteworthy that Japan is the only country, which has the formula and the standard such as mentioned above. Owing to the technologies and half century long experience of artificially frozen ground engineering, our frozen soil engineering expertise can manage the frost heave amount and the thaw-settlement in the order of millimeters.

In the early 21 century, two permafrost engineering related national projects had carried out under the governmental strategy. One was the R&D on the design methodology of chilled gas pipeline in permafrost regions and another one was the continuous production experiment of methane hydrate in arctic regions. The former one was the R&D collaboration with Gazprom of Russia but was stopped in 2014 right after the annexation of Crimea by Russia. The later one was the R&D collaboration with the geological survey of Canada and was completed successfully. As the result, there is no R&D activities on permafrost engineering in Japan now. However, some kind of R&D activities on frozen soil engineering related to the artificial ground freezing and LNG in-ground storage tank are carrying out. The total engineers working on this field now is about 50 to 60 in Japan. It means that a few engineers are expected to join in this farm annually in Japan. However this number is not big enough to keep the course of frozen soil engineering in universities.

One good solution we have now in Japan is to initiate the project such as shown in Fig. 2. This project is one of the 12 big R&D activities in Cross-ministerial Strategic Innovation Promotion Program (SIP) and is named "Development of Innovative Technologies for Exploration of Deep Sea Resources" of which annual budget is about 20 million USD and hundreds of scientists and engineers have got job under this project. The main contractor is JAMSTEC.

Last year our Minister of Foreign Affairs of the Japanese Government has declared that Japan will contribute to the sustainable development of arctic regions. So, if the National Institute of Polar Research (NiPR) can promote some kind of R&D project such as mentioned above like JAMSTEC, pretty many young scholars can have opportunity to study Cryosphere engineering and then the technology transfer to the next generation may available. In order to progress the project making, the scenario of the project is important, and then promotion of the project to the farm which will select the project is also important. If NiPR and/or ARC will try such a kind of project initiation, the member of this activity may help the scenario making.

Acknowledgments

The authors are grateful to the Hokkaido University Arctic Research Center for study funding. The authors acknowledge the suggestions for this study provided by Professor Masato Tanaka of Hokkaido University.

This work was carried out under the program of the Japan Arctic Research Network Center (J-ARC Net).

Summary in Japanese 和文要約

氷海構造物設計指針 ISO19906 と凍土工学に関する研究

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2019 年 7 月に刊行された ISO19906 改訂版の概要と日本における凍土工学の研究の今後の展開と技術の継承について考察した。

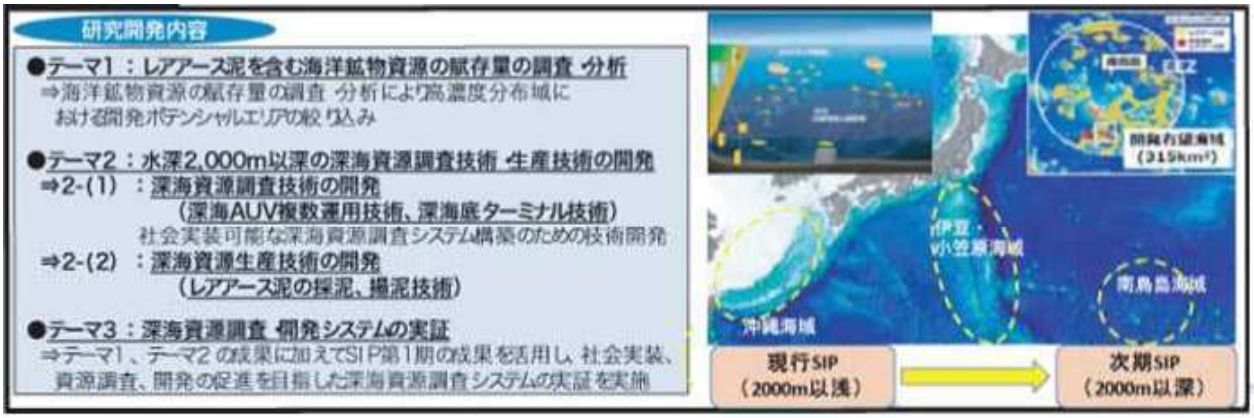

Fig. 2 SIP project named "Development of Innovative Technologies for Exploration of Deep Sea Resources."
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