PORT WORKS DESIGN MANUAL

CORRIGENDUM No. 1/2020

This corrigendum contains amendments to the Port Works Design Manual, 2002 Edition, and shall be read in conjunction with Corrigenda 1/2006, 1/2014 and 1/2018.

PART 3 – Guide to Design of Reclamation

(a) Section 2.6.1 – General

Add the following paragraph after the 1st paragraph:

In recent years, there is a tendency of not removing the sediment in reclamations, mainly on environmental reasons. Apart from the drained method, other types of soil improvement techniques can be considered. These are described in the ensuing paragraphs.

(b) Section 2.6.7 – Other Soil Improvement Techniques

Replace Section 2.6.7 by the following sections:

2.6.7 Deep Cement Mixing Method

(1) Introduction of Deep Cement Mixing

The principle of deep cement mixing (DCM) is based on chemical reactions between clay and chemical agents. Ordinary Portland Cement and Portland Blast Furnace Cement, etc. are the most commonly used admixture stabilizers. The purpose of mixing chemical agents with the soil is to improve the stability, strength and stress-strain properties of the soil. The stabilization mechanism generally involves the following chemical reaction processes :

- Cement reacts with the pore water of soft clay to form a series of hydrates.
- Hydrates exchange ions with clay particles and form large conglomerates.
- Clay particles react with the excess calcium ions from the hydration process and are bonded together.

The design considerations and design approach of DCM method for the foundation of seawalls and breakwaters are given in Section 4.5.2 and Section 4.6.2 of Part 4 of the Manual respectively. For reclamation, designer could consider, apart from conventional reclamation methods (including drained method and dredged method), using DCM as one of the non-dredged methods to form land by strengthening in-situ soft marine sediment.

(2) Advantages of Deep Cement Mixing

The advantages of DCM method as compared with conventional reclamation methods are :

- DCM method solidifies the soft marine sediment by mixing it with cement slurry to form DCM columns in a shorter time frame to support the seawall and filling materials above, thus reducing the time required for reclamation. The reclaimed land could be delivered for early development.
- DCM method is an environmental friendly method as it does not require dredging of marine sediment and importing materials for filling back the dredged area. DCM method can also significantly reduce the consolidation settlement arising from conventional drained method. Hence, the demand for importing fill materials would be reduced and disposal of dredged marine sediment would also be minimized.
- DCM is flexible in application because the amount of stabilizing agent and form of treatment can be adjusted to suit different soil properties and engineering requirements.

(3) Considerations of Deep Cement Mixing

The following considerations should be taken into account in the choice of reclamation method :

- The cost of DCM method may be higher than that of a conventional reclamation method.
- Stringent quality control and monitoring is required during the mixing process to ensure that the required strength is developed in the soil. It may be necessary to carry out field trials to obtain or verify design parameters and construction method statement for practical application, such as an optimal site-specific soil to cement ratio, water cement ratio, blade rotation number, etc.
- The rotating blades of the DCM machine may not work properly if obstructions of size larger than 250 mm are encountered during the mixing process.
- Investigations should be carried out to assess the possible environmental impacts associated with marine application of DCM and to determine if mitigation measures are necessary for a particular site. Site trial demonstration may be required. The time implication should be considered.
- It does not work well in certain soils, notably those which have a high organic content and acidic soils (Suzuki, 1982).
- It may not be applicable for very stiff or very dense ground or for treatment depth more than 40 m for land construction (Bruce, 2000) and 70 m for marine construction (Kitazume and Terashi, 2013).
- The change of unit weight of deep mixed zone is not significant. Therefore, no noticeable additional surcharge will be induced on the underlying soil strata due to the DCM stratum.

- The design of DCM works shall take into consideration the future land use and control the residual settlement to the acceptable level. The design consideration includes the geological conditions, treatment depth, design strength of DCM columns, spacing of DCM columns, filling depth and overburden pressure etc.
- The layout of DCM works shall be designed to cater for any horizontal stress arisen during construction and/or in the permanent state.
- The future developers of the land should be alerted to the modified ground conditions as the variability of sub-soil properties shall be taken into account during their foundation design and construction works.
- For pile foundation design, designer shall take into consideration the properties of DCM-treated soil in determining piling design layout and construction method, with a view to penetrating through DCM-treated soil to a deeper stratum for assuring pile capacity and reducing settlement of the superstructure.
- If DCM stops penetration in marine sediment without fixing on hard stratum (i.e. floating type improvement), some amounts of ground settlement will take place in the marine sediment beneath the DCM.
- The operation of DCM may cause heave and horizontal displacement of ground. The amount of ground deformation depends on the improvement area ratio and construction sequence.
- Spoils from DCM operation require treatment and/or disposal.

2.6.8 Other Soil Improvement Techniques

Soft deposits may also be strengthened in-situ by vibro-replacement (stone columns) or by soil mixing techniques including lime columns or any other soil improvement techniques. Other form of seawall construction methods or combination of methods may also be considered (e.g. using cofferdam steel cells sinking to hard stratum). Designers should consider the cost implications and possible effects on piling and excavation in future land development. These specialist techniques may require detailed assessment to demonstrate their viability.

(c) REFERENCES **Add the following references:**

Bruce, D. A. (2000). An Introduction to the Deep Soil Mixing Methods as Used in Geotechnical Applications, Publication No. FHWA-RD-99-138. U.S. Department of Transportation, Federal Highway Administration, Virginia.

Kitazume, M. and Terashi, M. (2013). The Deep Mixing Method, CRC Press,

Taylor & Francis Group, 410p.

Suzuki, Y. (1982). Deep Chemical Mixing Method using Cement as Hardening Agent. Proceedings of the International Symposium on Recent Developments in Ground Improvement Techniques, Bangkok, pp 299-340.