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Land Reclamation In Southeast Asia

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ABSTRACT: Reclamation is a widely accepted method for obtaining land in Southeast Asia. For placement method, hydraulic filling using marine source is commonly used. Suction dredgers are widely used to win marine sand for reclamation projects. With well planing and designs, these dredging vessels can supply millions cubic meters of fill in a clean and effective manner. The custom built suction dredgers used for the reclamation project in Mailiao, Taiwan are excellent examples and is discussed in details. Densification is generally required to improve the strength of hydraulic fill and reduce its settlement. Many densification methods applied in reclamation projects in the Southeast Asia region are also introduced.

INTRODUCTION

Countries in East Asia have been reclaiming land from the sea as a solution for satisfying the ever-increasing demand for land since the 19th century. The reconstruction after 1945 and the economical growth since then required extensive civil engineering infrastructure on reclamation areas. Reclaimed lands have been widely used for harbors, wharves, airports, power plants, industrial and commercial developments, and so on. Due to the rapid growth in recent years, more and more vast scale reclamation projects have been carried out in this region.

Dredging is a very cost-effective method in placing marine sand source to the designated area. The plain suction dredgers are valued tools not only for inshore sand reclamation but also offshore sand reclamation. Also, the selection of dredgers is directly related to their capability to operate under the prevailing sea conditions. This paper concentrated on the discussion of a successful land reclamation project using the custom built plain suction dredgers at Mailiao, Taiwan. In addition, the land reclamation works in the Southeast Asian region was briefly introduced. The improvement techniques commonly used on land reclamation projects were also given.

LAND RECLAMATION IN SOUTHEAST ASIA

Reclamation in Southeast Asia can be dated back to the mid-nineteen century. Shortly after 1841 minor reclamation took place along the shoreline of the Hong Kong Island (Guilford, 1997). In Tokyo, medium scale reclamations took place from 1860 to 1960 (Hamasuna et al., 1991). However, large scale of reclamation emerged after 1945 as the solution for the pressure of increasing population and the economical growth in many other countries. The history and development of land reclamation in Southeast Asia were reported in the literatures.

Brand (1996) reported the latest projects while Guilford (1997) reviewed the history of reclamation in Hong Kong. Development of reclamation in Singapore was reviewed by Wei (1997). Aun (1998) described the recent and present planning of peninsula and island type of reclamation in Malaysia. Gouw (1997) and Ann and Yee (1997) reported recent major reclamation projects in Indonesia. In Taiwan, the reclamation activities were described in the governmental publications such as Kaohsiung Harbor Bureau (1971) and Research Institute of Transportation (1993). A review of reclamation in Philippines was outlined by Wang (1998). Hamasuna et al. (1991) described the history of reclamation in Tokyo. Some major island type reclamation for harbor facilities were described by Miyanaga et al. (1991). The above-mentioned literatures are only examples to show the awareness of the profession in this engineering discipline.

Land use of the reclaimed sites varied from residential area, recreational area, and industrial park to sanitary landfill. In the 1970's the size of the reclamation sites for housing purposes generally varied from 200 to 300 hectares. During the period between 1980's and 1990's, the scale of land reclamation in Southeast Asia became larger and larger. As shown in Table 1, the Chep Lap Kok Airport in Hong Kong was housed on a 920-hectare reclaimed platform which were formed by 206 million cubic meters of fills. For industrial developments, thousand hectares of reclaimed lands were created in Taiwan during the 1990's. The projects presented in Table 1 indicates that winning sands from marine source is a vital part of the reclamation projects.

Table 1 Major Reclamation Projects in Southeast Asia

City/Country	Project	Total Area of Reclamation, (hectare)	Quantity of Marine Fill, ($x10^6$ m^3)	Total Quantity of Fills ($x10^6$ m^3)	Year of Reclamation	Main Dredgers	Reference
Hong Kong	Chek Lap Kok Airport	920	76	206	1991-1992	Trailing suction hopper dredgers	Brand (1996), Oakeree(1992)
Osaka, Japan	Kansai Airport	511	2	178	1988-1991		Nakase(1987)
Singapore	Changi Airport	645	40	40	1976-1979	5 cutter suction dredgers	Choa (1980)
	Changi East Phases 1A and IB	1550	210	210	1992-1997	3 trailing suction hopper dredgers	Choa (1996)
Taiwan	Changhua Industrial Park	3578	147	147	1996~2000	3 cutter suction dredgers	Seto et al. (1996)
	Mailiao	2250	74	74	1994-1997	2 plain suction dredgers	Kao & Elshout (1995)

A NEW METHOD USED IN COASTAL LAND RECLAMATION AT MAILIAO, TAIWAN

Background

This section is devoted to a successful method of dredging marine sand for land reclamation under difficult heavy weather conditions at Mailiao, Taiwan. The reclaimed land is for the use of the "Formosa Plastic" Company's petroleum cracking refineries. The operation took place approximately 60 km south of Taichung and comprises the construction of a port for seagoing vessels, dredging an estuary and creating 2250 hectares of new land that is about 3m above the sea level. The sandy fill was dredged from marine borrow areas up to 12 km away from the reclamation sites. The project began in July 1993 with a search for suitable dredging equipment by both the contractor and the owner. The first idea was to deploy a couple of big cutter dredgers, which had to meet the demanding local conditions. There were two marine borrow areas for this reclamation project. Borrow Area I contained 13 million m^3 in shallow water, which was 2 km from a river estuary. Dredging at this area was restricted to a depth of 8 m and the tidal range was approximately 2 m. The pumping distance between this borrow area and the site was ranging from 5 to 7 km. Borrow Area II, which the location for a deep water port, is approximate 4 km offshore and provided 61 million m^3 fills. The depth of the port is ranging from 16 to 21 m. The pumping distance was ranging from 1 to 7 km. The soils in these borrow areas were mainly silt and fine to medium sand.

The meteorological condition of the offshore area is severe. During the summer months (April to September) the surface of the sea is smooth, but there is a chance of an occasional typhoon. During winter months, a strong Northeast monsoon prevails accompanied with long heavy swell. The local dredging industry had the experience that medium size dredgers can only work for between 100 to 120 days a year.

The nearest refuge harbors are Taichung, 60 km to the north, and a small fishing port, 50 km to the south.

Design Requirements

In addition to the unfavorable marine environment, the dredging fleet should satisfy the following requirements:

1) The project had to be completed within 4.5 years.
2) For future projects the dredgers would have to be deployed for sand winning approximately 10 km offshore. The seventy-four million m^3 fill of the reclamation project is barely 10% of the total volume to be dredged.
3) The dredgers must be able to work in both shallow and deep waters.
4) The dredgers had to be suitable for adoption at a later stage in order to level the bottom of the harbor.
5) The dredgers would have to begin working in early summer 1994 in order to enjoy the summer conditions as long as possible. This was probably the most difficult requirement, because it was July 1993 already when initiated the design of the fleet.
6) The new dredgers would have to deliver the highest possible output against the lowest possible price.

Plain Suction Dredgers

The solution for satisfying all those requirements was the deployment of plain suction dredgers. Against the odds, this solution was simpler than initially expected. The idea of building very large cutter dredgers was dropped, because this would require a long time for negotiations, extensive technical preparations, building and delivery. Deployment of readily available medium size cutter or wheel dredgers was out of the question, because too many craft would be necessary, and they would be hampered by the 120 days a year operating limit. To save time, the solution had to be sought in optimizing existing designs and in the use of as many standard components as possible. After careful evaluation, a newly launched Dutch plain suction dredger, the "IJsselmeer", met the conditions of this project. The "IJsselmeer" dredger works excellently in the soil where only cutter dredger could work previously. In addition, the soil at Mailiao is even easier for the "IJsselmeer" dredger to dredge than the soils that the "IJsselmeer" dredger used to work in.

The major design concept of the plain suction dredgers follows those of the "IJsselmeer" dredger. The major dimensions and power plant of the dredger are shown in Table 2. An underwater pump is connected at the bottom of the ladder. The pump is driven by deck-mounted engines that operating through a pivoting gearbox. The pivoting gearbox is of heavy duty and moves with the ladder. The engines are easy to maintain because of mounted on the deck rather than mounted below the deck. Other merits of this type of dredger are high fuel efficiency, ease of control, longevity and relatively low cost. Booster pumps were deemed necessary to bridge the large pumping distance. Two pump drives were chosen of the type used in the Beaver 3800 cutter dredgers. The double walled pumps had to be modified to withstand an end pressure of 24 bar.

Table 2 Major dimensions and power plant of the dredger

Major dimension:	
Overall length	72.1 m
Beam	14.9 m
Depth at side	4.25 m
Average draught (approx.)	2.25 m
Max. dredging depth (approx.)	34 m
Diameter of the suction tube	700 mm
Diameter of discharge pipe	700 mm
Power plant:	
For the submerged dredge pump	1,752 kW
For the dredge pumps on deck	(2x) 1,908 kW
For the jet pumps	876 kW
For on board network generator and hydraulic pumps	876 kW
For the harbor set	105 kW
Total installed power	7,425 kW

Optimization of Design

In order to increase production and bring down the cubic meter price, the average annual operational days had to be doubled. The target became 240 or even 250 days. In other words, the dredgers had to be able to dredge under heavy sea weather. Experience with seaworthy stationary dredgers was limited. Statistics for the area indicated that .75m could be assumed as a significant wave height, with a period of 7 to 9 seconds, which happens to be a dangerous long swell. If a craft could be designed to meet these conditions, only two dredgers would be needed for finishing the 74-million-cubic-meter fills in 4.5 years. Both the contractor and the dredger builder agreed to design the dredgers base on the conditions described previously with the considerations of winning sand from both shallow and deep water, optimizing the size of the craft, coupling the floating pipelines and providing ways for swell compensation for the suction pipe.

The design considerations of the suction pipe and the swell compensation system are as following:

1) The dredging operation was to begin in very shallow water.
2) Optimum production required to be able to dredging as deep as the authorities would allow. (Production of a plain suction dredger increases with the depth of the pit).
3) The system must be able to follow vertical and horizontal movements of about 10 m and yet retain enough stability to avoid production losses.
4) Compensation should preferably not be sought in the heavy wheel ladder, which would be complicated and hence prohibitively expensive.
5) The suction tube must be able to dredge through layers of consolidated silt.
6) The system should be able to survive the collapsing of deep pit.
7) The system must be able to free itself by continuing the dredging process as well as by pulling the suction tube free in a controlled manner and should not need emergency hoisting gear.
8) The system should be able to reduce the mixture concentration when pumping over long distance.
9) Servicing the suction head in heavy seas should be possible.
10) The system should be simple to operate.

Floating Pipeline

In order to fulfill above-mentioned requirements, special design features of the floating pipeline connection and the anchoring system were incorporated in the dredger design. Coupling the floating pipelines to a large extent dictates the maximum wave height in which the dredger can work. This could be done near the center of floatation. An additional advantage was that the pipeline would be well out of the way of the anchor cables and reduced the risk of damage significantly. The craft is designed to meet the Northeast wind on the stern, and the floating pipeline coupling meets the wind under a certain angle. The funnel-shaped support, built of anti-friction materials, made the coupling procedure easier and prevented kinks. The coupling can be used on the port as well as on the starboard sides. For working in heavy sea conditions, a quick coupling device and a heavy winch were incorporated. The heaviest anchor winch is on the stern. Calculations indicated that an anchor cable of at least 700m long would need a winch of only 480 kN. Furthermore, the craft has 4 side winches on the quarters and also a bow winch. The floating pipeline had a anchoring points every 70 meter.

Swell Compensation

The passive swell compensation system is another particular feature of the plain suction dredgers. Because the active swell compensation must be fed from sensors and needs a lot of energy, the option was ruled out. The passive swell compensation was triggered by the bottom contact. A suction tube with a closed end that rested on the seabed was developed. Two high-pressure water jets helped the bottom plate to enter the seabed if necessary.

Swell compensation took place from the top of the suction pipe that was suspended from one heavy wire. The system can tolerate a vertical movement of 10 to 11m and a wave period of 7 to 9 seconds. The wire ran to the suction-tube winch by way of the cylinder with a 5.5 m turn. This system was based on pre-pressurizing the hydraulic oil in the cylinder by using a pressure vessel to bring up much of the weight of the suction tube. While the ship heaves, the pressure on the foot of the suction pipe will always remain within the acceptable values, that is, between being hoisted free from the seabed and hitting the seabed too hard. Variation of forces in the hoisting wire caused by wave action was determined by a preset pressure. Hysteresis effects of the various sheaves' friction were taken into account. The pressure on the pit ground is a function of the weight of the suction pipe. It is influenced by the mixture concentration, the pressure of jets, the acceleration forces on the intermediate pipe, and the pulling of the swell compensation wire.

Summary

Two plain suction dredgers of 3000 m^3/hr in capacity were used for the Mailiao reclamation project. The marine fill was conveyed hydraulically to the site through floating pipelines of the diameter of 700 mm directly from the borrow source. Although development of the plain suction dredgers was not exactly simple and required a lot of computing, a sufficient stable system was ultimately been created. The dredgers were ordered in June 1993 and the first vessel arrived on site in April 1994, followed by the second one in July 1994. During the 9 months period the dredger builder not only performed the design and manufacture, the development of the automatic suction pipe and the swell compensation system, but also the model tests in the wave tank. The reclamation was completed in December 1997 that was 9 months ahead of schedule. This is also a benefit from a successful cooperation between the contractor and the dredger builder.

DENSIFICATION ON RECLAIMED LANDS

The hydraulic fills are generally loose, at the relatively density ranging from 20 to 60 %. Therefore, they may experience large settlement under static or dynamic loading. In addition, countries such as Taiwan and Japan are in seismic active regions that liquefaction of reclaimed land is a real hazard. Densification measures are necessary for the improvement of reclaimed land. Methods commonly used such as dynamic compaction, vibroflotation, and resonance compaction are discussed as following

Dynamic Compaction.

The dynamic compaction procedure is usually conducted in two steps, the primary pounding and the ironing pounding. The former is performed with higher energy and wider spacing between drop points to densify deeper zones. The latter is to smoothen out the craters formed at the primary step. The primary pounding is usually divided into 3 stages. The various factors that were adopted in major Southeast Asian reclamation sites are summarized in Table 3. It shows that pounders of 230 to 250 kN in weights and dropping at the heights ranging from 15 to 25m were generally adopted for the primary step, resulting the impact energy of 300 to 600 kN-m for a single drop. Depends on the required maximum depth of improvement, the total impact energy applied for the working panels ranged from 1600 to 5000 kN-m/m^2. The maximum depth of improvement is back-calculated from the empirical formula proposed by Mayne et al (1984). The back-calculated depths of improvement in Table 3 are in close agreement with the experience elsewhere in the world. Results of the trial compactions at the Haifong site (Lo, 1998) suggested that the dynamic compaction is not effective beyond 12 meter depth. On the other hand, Yu and Hsu (1997) observed that the maximum degree of improvement occurred at the depth of about one third of the influence. At that particular depth, the degree of improvement, the ratio of increment of in-situ test value and the pre-compaction value, is ranging from 40 to 50 %.

Vibroflotation

Vibroflotation refers to a process of sand compaction through the insertion of a vibrating poker or a vibroflot intr ground. The vibration provides the compaction energy tha causes instant settlement due to liquefaction. In general the vibroflot, which consists of a cylindrical body housing an electric motor and an eccentric mass, could provide th horizontal eccentric force. To assist penetration, water jet are fitted to the hose of the poker. To carry out compactio the vibroflot is lowered to the bottom of the soil layer, wit (wet process) or without the water jets (dry process), an then gradually withdrawn in 0.5 to 1.0m stages. The lengt of time spend at each stage depends on the soil reactior

Table 3 Case history of dynamic compaction for hydraulic sand

Site	Phase	Weight of Pounder W (kN)	Height of Drop H (m)	No. of Pass Per Grid	Spacing of Grid (m)	Total Energy (kN-m/m²)	Max Depth of Improvement d_{max} (m)	Reference
TAIWAN Mailiao	Working Panels	240 200	25 25	12-14 12-14	9 9	2820 Site I 3420 Site II	9 9	Chung et al. (1995); Pan and Hwang (1995); Wu et al. (1996)
		240 240	20 25	11-33	9-12 9-12	3000 5000	9 13	Yu and Hsu (1997)
Haifong	Trial Panel	250	20 20 25 25 25	18 22 18 26 58	8 10 8 12 18	5625 4400 7031 4514 4475	12 12 12 12 12	Lo (1998)
SINGAPORE Changi	Initial Phase	250	15			1250	6	Choa (1980)
Changi East	Phase 1A	230	25	10	6	1600	8	Choa et al.(1997)
		150	20	20	6	2350	8	

During the withdrawal of the vibroflot, granular backfill is very often placed into the ground through the annular void between the vibroflot and the ground so that compacted granular material is formed within a volume of soil compacted. When sand is used as backfill, the product is named sand compaction piles and when gravel is used, it is named as stone columns. On the other hand, there is a procedure that the compaction takes place in only one phase and without import of backfill material. This simplifies the operation. According to Debats and Sims (1997), depths up to 35m can be reached and both land and marine compaction can be carried out. In Taiwan, the vibroflotation technique is referred to the Sand Compaction Pile (SCP) method that uses ordinary vibratory hammers with pipe pile (Moh et al., 1981).

Table 4 summarizes the results of the vibroflotation technique in various reclamation projects in Southeast Asia that were reported by the professionals. The maximum depths of ground treatment range from 10m to 21m. Depends on the magnitude of the vibration energy, the spacing of the treatment point is ranging from 1.6m to 4.0m. The depth of ground treatment reached as much as 21m. Results of in-situ tests measured before and after compaction indicate the degree of improvement is as much as 300 %. Compared with the degree of improvement of 40 to 50 % that could be obtained by dynamic compaction, vibroflotation is a more efficient densification method.

Resonance Compaction

Vibrating probe methods for densification of hydraulic sand fill was adopted in Hong Kong (Hwang et al., 1996) and at Phase 1B of the Changi East Extension in Singapore (Choa, 1996; Choa et al., 1997). These methods utilized essentially vertical vibrations in the probe. Densification is achieved by using the resonance concept that was introduced by Massarch (1990). The vibrating probe excites the ground vibration at resonance frequency, thus amplifying the ground resonance and improving the efficiency of the compaction. According to Hwang et al. (1996), densification can be applied by the flexible probe for deep compaction, or by the rigid vibratory plate for shallow surface compaction. The vibratory probe system comprises a powerful hydraulic vibrator attaching to the top of a flexible probe to generate vertical vibration. Vibration sensors can be placed on the ground to measure the ground response. These measurements were sent to a computerized control unit that can adjust the vibrating frequency of the probe. The vibrating frequency is adjusted accordingly to the frequency that resulted in greatest ground vibration, which is also called nominal resonance frequency. Based on the experience of using the Resonance Compaction Method in Changi East Reclamation Phase 1B, Chao et al. (1997) concluded that the type of vibrator, spacing and duration of compaction and the selected frequency are important factors.

Table 4 Summary of case history of vibroflotation on hydraulic fill

Country/ Site	Vibroflot/Casing Dia. (mm)	Leng. (mm)	Wt. (kN)	Ecce. Force (kN)	Amplit. of Vibrat. (mm)	RPM	Process	Max. Thick. of Fill (m)	Spacing Of Grid (m)	Assessment Tests CPT MPa Pre-Comp.	CPT Post Comp.	SPT N value Pre-Comp.	SPT Post Comp.	Reference
Hong Kong West Kowloon Tai Ho Central	350	3500	21	300	23	1800	Wet	13	3.4-4.0	4-7	6-26			Debates and Sims (1997)
Chek Lap Kok	350	3500	22	450	32	1500	Wet							
Singapore Pasir Panjang				150 350	8-12 26			10	2.5 3.0	5-10 5-10	5-30 15-27			Aun and Yee (1997)
Changi East	350 360 350 400	3250 3300 3250 2900	22 25 25 24.4	280 330 450 290	23 28 32 25	1800 1800 1800 1775	Wet		2.5-3.0 2.4-2.6	3-6	15 15			Choa et al. (1997), Raju (1998)
Taiwan Mailiao	600	2500					Wet	17	1.9-2.4	3-6	7-11			Su et al. (1997),
Yung An	400						Dry	14	1.6-2.8	4-5	8-10	4-8	12-24	Chung et al. (1987)
Indonesia Arun	381	1860	18	100		1800	Wet	17	2.4			11-13	30-44	Gouw (1997)
Batam				400		3000	Wet	4-17	2.83	2-5	5-13			
Tarahan	400						Dry	21	1.8			2-4	6-11	

CONCLUDING REMARKS

Reclamation is a widely accepted method for obtaining land to house infrastructures, residential and commercial developments in Southeast Asia. For placement method, hydraulic filling using marine source is commonly used and is preferable than land-based source filling. Suction dredgers are widely used to win marine sand for reclamation projects. With well planing and designs, these dredging vessels can supply millions cubic meters of fill in a clean and effective manner. The custom built suction dredgers used for the reclamation project in Mailiao, Taiwan are excellent examples.

Densification is generally required to improve the strength of hydraulic fill and reduce its settlement. Many densification methods including dynamic compaction, vibroflotation and resonance compaction are successfully applied in reclamation projects in the Southeast Asia region. Quality control of the reclaimed lands can be done by establishing procedures and criteria for densification, and by using in-situ testing such as CPT and seismic methods to inspect.

Additional areas to be considered are: 1) Seismic effects should be given more consideration for reclaimed lands to prevent unexpected failure. The relative density of hydraulically placed fill may be about 60% at best, however, the value could be lower than 20% (Jefferies et al., 1988).

Therefore, the susceptibility to liquefaction of a hydraulic fill land is very high during seismic loading. 2) The reclamation process would inevitably cause various impacts not only to the coastal area but also to the surrounding marine environment. Therefore, the operation of the reclamation should minimize water and air pollution, damage to aquatic habitat, shoreline changes, etc. The surrounding region should be carefully conserved and mitigation may be necessary during the land development. 3) Cost/benefits analysis is critical in the selection of the placement method and the subsequent treatment of the reclaimed lands. The Mailiao project in the west coast of Taiwan is an excellent example for selecting the custom-built equipment to speed up the filling, thereby saving time and cost.

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REFERENCES

Aun, O.T. (1998) Land Reclamation in Malaysia, Special Session on Land Reclamation in Southeast Asia, Proceedings, 13th Southeast Asian Geotechnical Conference, Taipei, Taiwan.

Aun, O.T. and Yee, K. (1997). Some Recent Developments of Ground Improvement Technology in Southeast Asia. 30th Year Anniversary Symposium of the Southeast Asia Geotechnical Society, Deep Foundation, Excavations, Ground Improvements and Tunneling. Bangkok, Thailand, November, 1997, pp.1-81 to 1-106.

Brand, E.W. (1996). Role of Geotechnical Engineering in Hong Kong's Port and Airport Developments. Chin Fung Kee Memorial Lecture, Proceedings, the Twelfth Southeast Asian Geotechnical Conference and the Fourth International Conference on Tropical Soils, Kuala Lumpur, Malaysia, May 1996, Vol. 2, pp.51-70.

Choa, V. (1980). Geotechnical Aspects of a Hydraulic Fill Reclamation Project. Proceedings of the Sixth Southeast Asia Conference on Soil Engineering, Vol. I, May, Taipei, pp.469-484.

Choa, V. (1996). Soil Improvement in Large Reclamation Project, Special Lectures. Proceedings of the Twelfth Southeast Asian Geotechnical Conference and the Fourth International Conference on Tropical Soils, Kuala Lumpur, Malaysia, May 1996, Vol. 2, pp.93-112.

Choa, V., Bo, M. W., Arulrajah, A. and Na, Y. M. (1997). Overview of Densification of Granular Soil by Deep Compaction Methods. International Conference on Ground Improvement Techniques, May, Macau, pp.131-140

Chung, Y.T., Wu, W.K. and Chung, S.T. (1987). Improvement on Hydraulic Sandy Fills by Compaction Sand Piles. Preceedings of the 9th Southeast Asian Geotechnical Conference, Bangkok, Thailand, December, Vol. 11, pp.8-57 to 8-68.

Chung, Y.T., Yeh, C.C., Wu, W.K. and Yu, M.S. (1995). Application of Deep Compaction on Reclaimed Lands. Sino-Geotechnics, No. 51, September, pp. 67-78 (in Chinese).

Debats, J.M. and Sims, M. (1997). Vibroflotation in reclamations in Hong Kong. Ground Improvement, Vol. 1, pp. 127-145.

Gouw, T.L. (1997). Soil Improvement on Reclaimed Lands. The Indonesia Experience, 30th Year Anniversary Symposium of the Southeast Asia Geotechnical Society, Deep Foundation, Excavations, Ground Improvements and Tunneling, Bangkok, Thailand, November, 1997, pp.1-107 to 1-125.

Guilford, C.M. (1997). A Look Back: Civil Engineering on Hong Kong, 1841-1941. Asia Engineer, July, Vol.25, No. 7, pp.10-13.

Hamasuna, J., Kajiki, M. and Sima, M. (1991). Reclamation History of Port of Tokyo and its Future View in Tokyo Bay. Soil Mechanics and Foundation Engineering (Tsuchi-To-Kiso), Vol. 39, No. 1, Ser. No. 396 (in Japanese).

Hwang, J.T., Buckell, R. and Chow, C. (1996). Ground Densification Using Ground Resonance Vibration. Twelfth Southeast Asian Geotechnical Conference and the Fourth International Conference on Tropical Soils, Kuala Lumpur, Malaysia, May 1996, Vol. 2, pp.167-172.

Jefferies, M.G., Rogers, B.T. and Stewart, H.R. (1988). Island Construction in the Canadian Beaufort Sea. ASCE Geotechnical Special Publication, No. 21, Fort Collins, Colorado.

Kaohsiung Harbor Bureau (1971), Report on the Construction of the Extension Project of Kaohsiung Harbor (in Chinese).

Kao, T.C. and Elshout, J. (1995) A New Method Coastal Land Reclamation. 14th World Dredging Congress Dredging Benefits. Amsterdam, The Netherland, 14-17 Nov., 1995.

Lo, Y.F. (1998). Review of Soft Ground and Ground Improvement at Western Coast Areas. Technical Meeting No.481, Highways Bureau, Transportation Department, Taiwan Provincial Government, March 1998.

Massarch, K.R. (1990). Soil Compaction Using Resonance Technique. Symposium on Design, Construction and Testing on Deep Foundation Improvement: Stone Columns and Other Related Techniques, ASTM, STP, Philadelphia.

Mayne, P.W., Jones, J.S. and Dumas, J.C. (1984). Ground Response to Dynamic Consolidation. Journal of Geotechnical Engineering, ASCE, Vol. 110, No.6.

Miyanaga, S. and Takeyama, S. (1991). The History of the Reclamation in Kobe City. Soil Mechanics and Foundation Engineering, Vol. 39, No. 1 Ser. No. 196 (in Japanese).

Moh, Z. C., Ou, C. D., Woo, S. M. and Yu, K. (1981). Compaction Sand Piles for Soil Improvement. Proceedings 10th International Conference on Soil Mechanics and Foundation Engineering, Stockholm, Vol. 3, pp.749-752.

Nakase, A. (1987). Kansai International Airport Construction of Manmade Island. Proceedings of 8th Asian Regional Conference on Soil Mechanics and Foundation Engineering, July, Kyoto, Japan, Vol. 2, pp.87-101.

Oakervee, D. (1992). A look into the future - Hong Kong's new airport. Keynote Address, Proceedings of the Conference, "Asia Pacific - Quarrying the Rim", Hong Kong, pp. 5-15.

Pan, J. and Hwang, Z.M. (1995). Soil Densification by Dynamic Consolidation for Formosa Heavy Industries Corp., Formosa Plastic Group. Sino-Geotechnics, No. 51, Sep, pp.35-501 (in Chinese).

Raju, V.R. (1998) Vibro Compaction of Runway and Taxiway Areas at Changi Airport, Singapore, Proceedings, 13th Southeast Asian Geotechnical Conference, Taipei, Taiwan.

Research Institute of Transportation (1993), Study on Ground Improvement Technique for the Kaohsiung Deep-Water Harbor, Ministry of Communications (in Chinese).
Seto, Y.W., Ser, C.S. and Yang, W.H. (1996). Geotechnical Planning and Design of Hydraulic Fill Reclamation at Western Taiwan. Proceedings of '85 Harbour Geotechnical Engineering Symposium, January 1996, pp.11-1 to pp.11-21 (in Chinese).
Su, P.C., Juang, J.H., Chen, C.F. and Lin, J. (1997). The Soil Strength under a combination of stone column and Dynamic consolidation. Proceeding of the Seventh Conference on Current Researches in Geotechnical Engineering in Taiwan, August, Taipei, Vol. I, pp.517-524 (in Chinese).
Wang, H. (1998), A Cursory Review of Reclamation in the Phillipines. Special Session on Land Reclamation in Southeast Asia, Proceedings, 13th Southeast Asian Geotechnical Conference, Taipei, Taiwan.
Wei, J. (1997) Ground Improvement Techniques – The HDB Way, Preceedings, International Conference on Ground Improvement Techniques, May, Macau, pp.609-620.
Wu, W.K., Yeh, C.C. and Chen, L.F. (1996). The Improvement Effects of Dynamic Consolidation Method on Reclaimed Land. 12th Southeast Asian Geotechnical Conference, May, Kuala Lumpur, Vol. 1, pp. 253-257.
Yu, C.H. and Hsu, M.C. (1997). Evaluation of Dynamic Consolidation Method Applied in the Hydraulically Reclaimed Land. Proceedings, The Seventh Conference on Current Researches in Geotechnical Engineering in Taiwan, Vol. II, August, Taipei, pp.851-858 (in Chinese).