[Reference]

Overview of "Report of Study Results on Design and Construction of Ground"

An overview and the results of the examination of the design and construction, as well as the results of investigation of the environmental impact, in the “Report of Study Results on Design and Construction of Ground" (January 2019) are as follows.

[Overview]

- As a result of the soil survey, it was confirmed that there was a stratum that would have an impact greater than initially anticipated on the stability and subsidence of seawalls, etc., on the Oura Bay side of the planned site.
- Based on the ground strength, etc., obtained from the soil survey, the ground strength for seawalls, quay walls and reclaimed land on the Oura Bay side, where the target stratum (the stratum considered to have an impact the stability and subsidence of the seawalls, etc.) is distributed, was evaluated, and the design, construction, and environmental impact were examined.
- The subjects of the examination were the land reclamation and nine seawalls, etc.: the caisson-type seawalls (C-1 seawall, C-2 seawall, C-3 seawall, corner seawall, seawall (with mooring function)), the double steel pipe sheet piles (A seawall, partitioning quay wall A, partitioning quay wall B) and the rubble-mound breakwater (N-1 seawall).

[Results of the Examination of the Design and Construction]

○ Seawalls, etc.

- The required stability can be ensured through ground improvement using the sand compaction pile (SCP) method and the sand drain (SD) method.
- The maximum depth for SCP, directly below the C-1 seawall, is 70 m below standard sea level (CDL); however, construction is possible with existing work vessels in Japan.
  - ※ According to the “Current Work Vessel List 2017”, of the 19 sand compaction vessels registered in Japan, the maximum depth of penetration is 70 m for one vessel and 60 m for four vessels. The rest are 55 m or less.
  - ※ There are parts of the target stratum directly beneath the C-1 seawall that extend to a depth of 90 m; however, stability of the seawall can be ensured by conducting ground improvement to a depth of CDL 70 m.

○ Landfill (Oura Bay side)

・ Residual settlement due to ground improvement using the SD method is estimated to be about 40 cm over the 20 years from the start of service, and this can be addressed through appropriate maintenance and management, in much the same way as in the case of Tokyo International Airport Runway D, which is an offshore landfill airport similar to this project.

○ Construction process

・ The construction period required for ground improvement is about three years and eight months for offshore construction and about one year for onshore construction.
・ Eleven sand compaction vessels would be in operation from the first year to the second year. At peak times, as many as 92 work vessels, including sand carriers and tugboats, would be in operation.
・ The total number of sand piles required for ground improvement is 76,699 with SCP and SD improvements. Moreover, the total amount of sand required for the sand mat and ground improvement is about 6,509,000 m^3 in total for SCP and SD improvements.
・ The total amount of dredging due to ground improvement will be about 540,000 m^3 for the caisson-type seawalls and partitioning quay walls.

[Results of the Examination of the Environmental Impact]

○ Summary

・ If the ground improvement work is carried out using the SCP method, etc., the environmental impact may increase, with respect to air quality, noise, vibration, water turbidity caused by earth and sand (sea area), the impact of sea floor vibration on marine organisms, and the impact of underwater sounds on dugongs. Therefore, it is necessary to consider the amount of increase.
・ Of these factors, the environmental impact due to vibration is hardly expected to increase, and as for air quality, noise, vibration, water turbidity caused by earth and sand (sea area), the impact of sea floor vibration on marine organisms, and the impact of underwater sounds on dugongs, it will be possible to perform construction without the peaks exceeding the ranges assumed in the Environmental Conservation Book by making adjustments to the construction process.

○ Air quality

・ Based on the number of fleets of major work vessels set for ground improvement

work, the fuel consumption by fuel type, was calculated for work vessels and construction machinery, etc., and compared with the Environmental Conservation Book.

- The peak values of monthly fuel consumption by fuel type are 2,127,674L/day for heavy fuel oil A and 24,823L/day for diesel fuel in the fourth month of the third year in the Environmental Conservation Book. In the case of ground improvement work, heavy fuel oil consumption A is 330,659L/day in the fifth month of the first year, and diesel fuel is not used because, at that time, construction work will be offshore only. Comparing the peak values for monthly fuel consumption by fuel type associated with ground improvement work, it is about 16% of the peak value of fuel consumption in the Environmental Conservation Book.
- The total fuel consumption by fuel type during the construction period is 477,050kL for heavy fuel oil A and 30,616kL for diesel fuel in the Environmental Conservation Book, and 116,940kL for heavy fuel oil A and 899kL for diesel fuel for ground improvement work. Comparing the total fuel consumption of the Environmental Conservation Book and ground improvement work, the heavy fuel oil A used in ground improvement work is about 25% of the Environmental Conservation Book total, and diesel fuel is around 3%.
- The peak value of the increase in fuel used by work vessels and construction machinery, etc., in the ground improvement work is about 16% of the peak value for fuel consumption in the Environmental Conservation Book. It is considered possible to make adjustments to the construction process to ensure that the periods in which peak fuel consumption occurs for the construction work described in the Environmental Conservation Book and for the ground improvement work do not overlap. By making such adjustments, it will be possible to limit the peak of the impact on air quality to within the range of the forecast results of the Environmental Conservation Book, even when carrying out ground improvement work.

○ Noise

- Based on the number of fleets of major work vessels set for ground improvement work, the noise level contribution (estimated value) of the ground improvement work was examined. As for road traffic noise, the plan is for the sea sand for use in the ground improvement work to be transported in by land, and the noise level contribution (approximate value) of the equipment and material transport vehicles, etc., was examined, based on the number of dump trucks in operation.
- As for the construction work noise associated with the conducting of ground

improvement work, it was about 31 to 62 dB in the Henoko settlement, and about 30 to 61 dB in the National Institute of Technology, Okinawa College. The combined noise level when the construction work noise of the ground improvement work is added to that of the Environmental Conservation Book is about 61 to 65 dB in the Henoko settlement, and about 56 to 63 dB in the National Institute of Technology, Okinawa College, and both are lower than the threshold under the Noise Regulation Act (85 dB).

- The contribution to road traffic noise level (predicted point: Yofuke) is 0.4 dB, an increase of less than 1 dB, and as the construction period is short, just 2 months (9 to 10 months in the fourth year), the impact of road traffic noise from the movement of equipment and material transport vehicles, etc., is considered to be minimal. In addition, the periods during which the numbers of equipment and material transport vehicles, etc., are at their highest in the Environmental Conservation Book and in the ground improvement work are short, and adjustments can be made to the construction process to ensure that the respective peak times do not overlap. Even in the event that the number of equipment and material transport vehicles, etc., in operation increases because of the ground improvement work, the increase in noise level will be less than 1 dB, causing minimal change from the predicted results of the Environmental Conservation Book, and the environmental standards related to noise are considered to be met.

○ Vibration

- Based on the number of fleets of major work vessels set for ground improvement work, the vibration level contribution (estimated value) of the ground improvement work was examined. As for road traffic vibration, the plan is for the sea sand for use in the ground improvement work to be transported in by land, and the vibration level contribution (approximate value) of the equipment and material transport vehicles, etc., was examined, based on the number of dump trucks in operation.
- Because the ground improvement area is located at a distance of over 1 km from the Henoko settlement and the National Institute of Technology, Okinawa College, the contribution to vibration level at the predicted point is 0 dB due to the distance attenuation effect, so the construction work vibration associated with the ground improvement work is considered to have zero impact.
- The contribution to road traffic vibration level (predicted point: Yofuke) is 0.3 dB, an increase of less than 1 dB, and as the construction period is short, just 2 months (9 to 10 months in the 4th year), the impact of road traffic vibration from the movement

of equipment and material transport vehicles, etc., is considered to be minimal. In addition, the periods during which the number of equipment and material transport vehicles, etc., are at its highest in the Environmental Conservation Book and in the ground improvement work are short, and adjustments can be made to the construction process to ensure that the respective peak times do not overlap. Even in the event that the number of equipment and material transport vehicles, etc., in operation increases because of the ground improvement work, the increase together with the noise level will be less than 1 dB, causing minimal change from the predicted results of the Environmental Conservation Book, and the environmental standards related to noise are considered to be met.

○ Water turbidity due to earth and sand (sea area)

- Based on the amount of work set for ground improvement work, the amount of turbidity generated was calculated and compared with the Environmental Conservation Book.
- The turbidity generation load per month is 573t when carrying out embankment dredging for the seawalls and quay walls and when pouring in sand and improving sand drains in the landfill area. The peak value of turbidity generation load per month due to ground improvement work is 17 to 38% (16.6 to 37.6%) of the peak value in the Environmental Conservation Book.
- When the total turbidity generation loads per month are totaled to calculate the total amount for the construction period, it comes to 55,915 tons in the Environmental Conservation Book and 7,479 tons for ground improvement work, and the increase associated with the carrying out of ground improvement work is around 13% of the entire construction.
- The turbidity that occurs due to the conducting of ground improvement work, on the assumption that the sand is to be poured in, is considered to be about 13% of the total amount of turbidity generated for the entire construction according to the Environmental Conservation Book, and it is considered that no significant amount of turbidity will occur. In addition, it is considered possible to adjust the construction process to ensure that the periods during which the amount of turbidity is at its peak for the construction described in the Environmental Conservation Book and for the ground improvement work do not overlap, and by making such adjustments, it will be possible to limit the peak of the turbidity generated to within the range of the forecast results of the Environmental Conservation Book.

○ Seabed vibration (impact on marine organisms)

- The impact on marine organisms of seabed vibration associated with ground improvement work was examined, with reference to the impact predictions in the Environmental Conservation Book.
- New seabed vibration will be generated by the ground improvement work; however, since the seabed vibration will occur only during the daytime, and since the expected range of impact will be localized within a 300 m radius from the construction site, the impact of seabed vibration on marine organisms is almost unchanged from the predicted results of the Environmental Conservation Book.

○ Underwater sound (Dugong)

- Based on the number of fleets of major work vessels set for ground improvement work, the combined values of sound pressure and sound exposure level of the source of underwater sound were calculated and compared with those of the Environmental Conservation Book.
- With respect to the effects of underwater sound on dugongs, three items were examined: sound pressure level (peak value), sound pressure level (RMS (effective value)), and sound exposure level.
- When the maximum values of the underwater sound of the Environmental Conservation Book and the ground improvement work are combined, the minimum value of the sound pressure level increases by 8 dB for both the peak value and RMS, but the maximum value remains unchanged. Moreover, in the case of the sound exposure level, the minimum value increases by 13 dB and the maximum value increases by 1 dB.
- When ground improvement work is performed, the maximum value of the combined sound pressure level of the source is at the same level as the Environmental Conservation Book for both the peak value and RMS, and the maximum value of the combined sound exposure level is increased by 1 dB from that of the Environmental Conservation Book. For this reason, the impact of underwater sound on dugong during construction when ground improvement work is being carried out is considered to be almost unchanged from the predicted results of the Environmental Conservation Book.