Study of Diffused Result in CAO Fei-dian Sewage Deep Sea Discharge Engineering

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Abstract. The wasted water diffuser is an important engineering technology to protect marine environment. It is very important in the protection of water environment in port. The diffusion effect of sewage in the ocean depends on the study of the angle parameter of the diffuser in physical model test, and CAO Fei-dian sewage deep sea engineering was an example in this article. In the engineering, jet angle is 0 degree, and horizontal angle is 0 degree too. This design not only ensures that sewage is adequately diluted, but also that the marine environment is not disturbed. This technology will play an increasingly important role protection of marine environment in the future.

1. Outline
Wasted water diffuser is a new tool for ocean ecological protection. The Jet angle and the horizontal azimuth angle are the main parameters that affect the result of waste water dilution in diffuser. In this article, the CAO Fei-dian sewage deep sea discharge engineering is an example, the diffusion effect of sewage with different jet angle and horizontal azimuth angle was analyzed by physical model test. This technology can ensure the popularization of wasted water offshore engineering, and It lays a foundation for further research on ocean environmental protection engineering.

2. Study Current Status
The diffusion of California wasted water ocean disposal engineering[1] used a single opening structure on the main pipe. It is found that this method can meet the requirements of the standard, it's technically possible; the engineering of Australia wasted water offshore [2] used “I” shape diffuser, this diffuser is porous shape, the distance between the two risers is 21 meters, each riser has six jet holes; Malabar wasted water deep sea project[2] used “L” shape diffuser and each riser has eight jet holes; the physical model research in Boston wasted water deep sea project[1] shows that the sewage tends to accumulate at the top of the ocean When there are more than 8 jet holes, this will reduce the effectiveness of wasted water dispersion; Wilkinson studied the relationship between the full mixing time of sewage and seawater and the length of diffuser is studied, which shows that the length of diffuser is very important for marine protection. YU[3] studied the structure of diffuser for Tianjin south port sewage discharge project is studied, which ensures the actual operation of the project and improves the operation efficiency of the project; ZHAO[4] put forward a mathematical model for hydraulic calculation of diffuser is proposed to ensure the practical operation of the project; HUANG Xiao-ping [5] put forward the structure type of diffuser for Daya Bay waste water discharge project is analyzed by combining numerical simulation with physical model test, the influence of Jet Angle and Horizontal Azimuth Angle on marine environment is analyzed in this paper, the effluent uniformity under different sewage flow rate was also studied.
3. Case Study

3.1. Physical Model

Because the velocity of the jet near the sewage outlet is very different from that of the ocean, the mixing process of sewage and seawater has strong three-dimensional characteristics, so the conventional physical model should be used in the research. At present, there are many researches on the formula of model calculation, and the theoretical basis is different. The physical model is designed as shown in the following formula.

$$R_{ej_{min}} = \frac{u_{j_{min}}D_{min}}{\nu} \geq R_{e_c}$$

$R_{ej_{min}}$—the aperture Reynolds minimum of this study; $u_{j_{min}}$—the minimum aperture flow rate in physical model(m/s); $D_{min}$—The minimum Coefficient in physical model(m); $\nu$—the flow coefficient; $R_{e_c}$—major Reynolds Coefficient.

3.2. Study Conclusions

Conclusions of different horizontal azimuth

The horizontal orientation of the vent is directly related to the influence of the path of the sewage jet and dilution diffusion on the project. There are three schemes, including 0, 30 and 90 orientation angles as the physical model test schemes. The results are shown in tables 1 and 2.

| Tides     | Distance | Mixing area     |       |       |       |
|-----------|----------|-----------------|-------|-------|-------|
|           |          | 80m             | 180m  | 480m  |
| Rise tide | 50m      | 168.7           | 211.6 | 280.2 |
|           | 70m      | 245.4           | 290.4 | 321.6 |
| Fall tide | 50m      | 202.7           | 219.7 | 289.9 |
|           | 70m      | 89.3            | 306.2 | 340.3 |
| Advection | 50m      | Diffusion area:0.039km² |       |       |
|           | 70m      | Diffusion area:0.042km² |       |       |

| Tides     | Distance | Mixing area     |       |       |       |
|-----------|----------|-----------------|-------|-------|-------|
|           |          | 80m             | 180m  | 480m  |
| Rise tide | 50m      | 145.1           | 218.8 | 259.2 |
|           | 70m      | 189.4           | 249.6 | 301.3 |
| Fall tide | 50m      | 151.8           | 219.1 | 275.4 |
|           | 70m      | 210.1           | 255.8 | 307.7 |
| Advection | 50m      | Diffusion area:0.052km² |       |       |
|           | 70m      | Diffusion area:0.055km² |       |       |

When the horizontal azimuth angle is 0 degrees, the jet perpendicular to the flow direction has the best effect on the initial dilution of the environment because of the rapid mixing of sewage and seawater. Because of the deep sea water depth, it is not easy to form sewage mass on the sea water
surface, which is beneficial to the secondary dilution and diffusion of sewage and has little influence on the environment.

Conclusions of different jet

The jet angle is one of the most important factors affecting the dilution of wastewater, which is very important for the initial mixing of wastewater. The choice of jet angle is the basic condition in the study of diffuser in this project. According to the actual situation of this project, the jet angle can be divided into 0, 10 and 15 schemes, which can be verified by physical simulation test. The results are shown in tables 3 and 4.

| Tides      | Distance | Mixing area  | 80m | 180m | 480m |
|------------|----------|--------------|-----|------|------|
| Rise tide  | 50m      |              | 173.6 | 215.2 | 280.1 |
|            | 70m      |              | 250.1 | 276.4 | 316.8 |
| Fall tide  | 50m      |              | 198.5 | 222.3 | 301.8 |
|            | 70m      |              | 270.2 | 296.1 | 349.5 |
| Advection  | 50m      |              |       |       | Diffusion area:0.041km² |
|            | 70m      |              |       |       | Diffusion area:0.045km² |

| Tides      | Distance | Mixing area  | 80m | 180m | 480m |
|------------|----------|--------------|-----|------|------|
| Rise tide  | 50m      |              | 142.6 | 162.8 | 220.3 |
|            | 70m      |              | 270.6 | 235.5 | 271.6 |
| Fall tide  | 50m      |              | 159.5 | 178.2 | 242.9 |
|            | 70m      |              | 291.3 | 260.5 | 277.6 |
| Advection  | 50m      |              |       |       | Diffusion area:0.030km² |
|            | 70m      |              |       |       | Diffusion area:0.033km² |

The experimental results show that the longitudinal mixing is related to the shape of the jet angle, and the larger the jet angle is, the larger the vertical jet is, at the same time, the cross-mixing of jet and cross-flow is slow, and the jet width increases. When the Jet Angle is 0, it is difficult to form sewage mass due to the strong disturbance of environment flow and the sewage has certain drift distance, so the engineering can achieve better dilution and diffusion. According to the actual water depth, it is suggested that the jet angle of diffuser is 0.

Conclusions of different distance

The distance of diffuser is one of the key factors affecting the success of sewage discharge project. Due to the high demand of water quality in the wastewater discharge area of the project, different 50m ~70m diffuser length schemes are selected to carry out physical model tests, and the diffuser length schemes are determined according to the test results.
Table 5. 50m diffuser; 0° horizontal azimuth angle; jet angle 0°

| Tides        | Distance | Mixing area |
|--------------|----------|-------------|
|              |          | 80m         | 180m | 480m |
| Rise tide    | 50m      | 180.6       | 218.4 | 285.3 |
| Fall tide    | 50m      | 202.9       | 221.5 | 301.1 |
| Advection    | 50m      | Diffusion area: 0.036km² |

Table 6. 70m diffuser; 0° horizontal azimuth angle; jet angle 0°

| Tides        | Distance | Mixing area |
|--------------|----------|-------------|
|              |          | 80m         | 180m | 480m |
| Rise tide    | 70m      | 237.8       | 259.6 | 287.5 |
| Fall tide    | 70m      | 255.2       | 276.1 | 301.6 |
| Advection    | 70m      | Diffusion area: 0.045km² |

The experimental results show that the two-stage diffusion length can meet the requirements of initial dilution. When the diffusion length reaches 70m, the effect of sewage diffusion is more obvious, the sewage is fully mixed with the surface sea water, which shows that the number of riser pipe meets the design requirements. It can be concluded that the 70-meter-long diffuser can meet the design requirements of diffuser and marine environmental protection.

4. Research Conclusion

Through the study and analysis of hydraulic model test, the distance of diffuser is 70-meter-long. As the depth of the sewage outlet is about 7m, it is recommended that the horizontal azimuth angle is 0°, the jet angle is 0° too. This type of design can not only ensure that wasted water and seawater are fully mixed to meet the requirements of hydraulic design, but also can avoid the formation of sewage mass in the sea. Based on the results of physical model test of CAO Fei-dian wastewater marine treatment project, the following laws can be obtained: in deep water, the better dilution and diffusion can be ensured by increasing the jet angle and horizontal azimuth angle of the diffuser, it can ensure the good operation of the wasted water deep sea disposal engineering. To sum up, it is the main technical means of harbor engineering and marine ecological protection to study diffuser structure through physical model experiment.

5. Reference
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