Reduction and Resources Treatment of Construction Waste Slurry

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Reduction and Resources Treatment of Construction Waste Slurry

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Abstract: A set of technological scheme of reduction and resources treatment was put forward according to the dehydration mechanism of construction waste slurry. The influence of conditioner on flocculation dehydration was analyzed. The flocculation effect of flocculant on construction waster slurry was explored. The moisture content of hydrated construction slurry was measured after pressure filtration dehydration. By comparing the experimental results of three kinds of sludge, it is found that it is ideal to select metal ions as conditioning agent, inorganic flocculation combined with anionic polyacrylamide as flocculant for the construction waste slurry, which was cooperated with previous sand separation and flocculation and concentration alternately for a few times. Finally the moisture content of the mud cake after dehydration with press filter machine was under value of 30%.

1. Introduction

The construction of construction cast-in-place pile includes grouting pile, rotary bored grouting pile, punching pile, long auger bored grouting pile, dry working pile and sinking pile. In the process of cast-in-place pile drilling, slurry wall-protection technology is usually adopted. The amount of drilling slurry is usually 3~5 times of the volume of the hole[1]. The slurry discharge is large and water resources are wasted seriously. Niu Jiewen[2] proposed the new rapid drilling slurry treatment technology, which can recover about 91% of the slurry and achieve the goal of slurry reduction. However, with the increasingly densification of urban buildings, the amount of waste slurry is increasing. The treatment and disposal of the waste slurry has always been a difficult problem for engineering construction, and has gradually become a prominent problem in the economic and social development. Because the waste slurry contains a large amount of clay, sandy soil, gravel soil, weathered rocks, minerals and debris, it has a high consistency, which cannot be directly discharged, and natural sedimentation is difficult. Up to now, two methods have been used to treat waste slurry, one is solidification, and the other method is solid-liquid separation method[3]. Its solid content is about 15%~25% and its density is generally between 1.2 and 1.46 [3], which is larger than that of municipal sludge. Therefore, it is difficult to be precipitated and requires a large flocculant dose. And the flocculation effect of general flocculants on it is not obvious. Solidification treatment requires a good curing agent with a longer curing time and a larger site, which is generally not used abroad, but mainly for the solid-liquid separation method. At present, the comprehensive development of disposal of construction waste slurry has not been carried out in in China. The widely used slurry treatment means include off-site and on-site treatment in China. The off-site approach is using the pipeline or truck to transport slurry outside the city and wait for its natural drying, or dumping it and collecting in
a space, treated as the sedimentation tank, which needs the government corresponding policies, providing the corresponding disposal sites and treatment costs, etc. Without government support, some companies could not afford the treatment cost and solve the difficulty. Therefore, most of the construction of slurry treatment will be simply handled in the site. In this way, it is necessary to study the solid-liquid separation of slurry and reduce its volume and pollution to the surrounding environment, so as to achieve the purpose of civilized construction and effective environmental protection. Since the existing treatment and disposal methods have problems of low efficiency and high cost[4], in order to meet the national environmental protection requirements and reduce the treatment cost, it is necessary to find a mature technology so that construction waste slurry can achieve the treatment objectives of reduction, harmlessness and resources.

2. Treatment technology

The solid-liquid separation method starts with a simple sand-stone separation for waste slurry, followed by chemical de-stabilization and flocculation treatment. Then the slurry-water separation is conducted by using the filtration method, mechanical dehydration equipment and filter bags. After solid-liquid separation, the moisture content of the solid phase is greatly reduced and the volume is reduced. The separated water can be directly discharged or reused after reaching the standard. Sloan et al.[5] have made a comprehensive comparison of different dehydration methods with the pilot plant, believing that the dehydration of sludge by the press filter machine results in high solid content and low energy consumption. Therefore, the press filter machine is adopted for the mechanical dehydration in this paper.

Fig. 1 is the solid-liquid separation process diagram for the treatment of construction waste slurry, and the specific technological process line is in the dotted frame. In the construction site, the waste mud pump will be delivered to the entrance of the treatment equipment. Firstly, a vibrating screen is used to isolate larger particles of slurry. Secondly, the sand is separated by the belt type sand-sorting machine. The belt type sand-sorting machine adopts the principle of mesh belt continuous filtration, which integrates mud dilution, high-pressure cleaning of sand, vibrating slapping and mesh cleaning, and has the ability to separate sand and stone in the slurry with high efficiency and large capacity. Then, in order to improve the flocculation effect, the slurry was recuperated before flocculating agent was added for the instability. Through experimental study, it is found that the addition of metal ions can invalidate the sodium carboxymethyl cellulose (CMC) in slurry, which was added in the slurry as a retarder for construction. The invalidation of CMC is conducive to flocculation. In order to improve the dehydration performance, three times of flocculation and two times of concentration were carried out before the dehydration of the press filter press. Most of the free water in the rectified and flocculated slurry is separated by the enrichment facility. The water quality of this part is relatively clear, which generally has reached the standard of national sewage comprehensive discharge level II. The slurry is flocculated before each concentration, and after two times of concentration the slurry is flocculated again and then enters the special high-efficiency belt press filter for dewatering. Under the effect of the special high-efficiency dewatering filter belt, the mud cake with low water content is obtained. The filtrate and belt cleaning water return to the conditioning, flocculation and concentration.

3. Experiments and results

Waste slurry from a construction site in Foshan contains sand and gravel. The operation of separating the sand and gravel is carried out before conditioning. The first step is to isolate the large particle of
stone through a vibrating screen with an aperture of 10 mm, leaving the stones no larger than 10 mm. It then passes through the sand separator which may remove all particles with the aperture greater than 0.25 mm. And with the high-pressure water cleaning, cleaner sand can be obtained for easy reuse.

3.1 Conditioning solution
At home and abroad, less systematic research has been carried out on the direction of construction slurry dehydration performance conditioning. Based on the actual needs of engineering in China, this paper designs a new construction slurry dehydration conditioning solution through experiments. According to a lot of engineering practice experience[6], the sludge is difficult to be dehydrated when its specific resistance is greater than \(100 \times 10^{11}\) m/kg; it is moderately difficult to be dehydrated for the case of the value \((99 \sim 1) \times 10^{11}\) m/kg; it is easy to be dehydrated while less than \(1 \times 10^{11}\) m/kg. In general, construction slurry is within medium dewatering difficulty. The waste slurry at a construction site in Foshan was used as the test sample, and the measured specific resistance of sludge was about \(87 \times 10^{11}\) m/kg. The conditioning experiment was conducted in the laboratory, as shown in table 1. The specific resistance of sludge was changed with different decreased values after the addition of different conditioners, and the moisture content after dehydration was also different. It can be seen from table 1 that adding metal ions to slurry can better reduce the specific resistance of sludge and improve dehydration performance. When the calcium chloride was added, the specific resistance of sludge was decreased to be \(0.5 \times 10^{11}\) m/kg, which made the sludge be dehydrated easily. Thus the moisture content after press filter dehydration was only 28.39%.

| Conditioner         | Acetic acid | Quicklime | Sodium hydroxide | Calcium hydroxide | Calcium chloride |
|---------------------|-------------|-----------|------------------|-------------------|-----------------|
| Specific resistance of sludge /\(\times 10^{11}\) m/kg | 72          | 39        | 60               | 11                | 0.5             |
| Moisture content of mud cake/% | 63.76       | 58.13     | 61.89            | 44.76             | 28.39           |

3.2 Experimental comparison with other sludge
The pH value of construction waste slurry is weakly alkaline, with an average value of 8.97. The active sludge in sewage treatment plants is usually neutral or slightly acidic due to the microbial activity, so their physical conditioning is different. The average concentration of waste construction slurry is 153.61 g/L, higher than that of active sludge (generally less than 12 g/L). The average dry solid organic matter content of slurry was 8.43%, and the average dry solid organic matter content of active sludge was higher than 30%. The mud cake formed by dewatering is less compressible than that of active sludge. The original moisture content of slurry ranges from 78% to 85%, while the initial moisture content of active sludge generally ranges from 90% to 99%, and the corresponding solid content is relatively low. The difference of these three properties shows that using the treatment and disposal of active sludge in sewage treatment plant to adjust the construction slurry obviously requires a huge amount of dose, and the effect is not good. Besides, the cost of active sludge conditioning is much lower than that of construction slurry conditioning.

The surface of construction slurry solid particles is negatively charged, and the surface potential ranges between -16.7 mV~28.6 mV, while the surface potential of active sludge ranges between -15 mV~10 mV. The suspension state of active sludge is relatively stable, but after long-term static, it will naturally fall into stratification under the effect of gravity. However, the construction slurry solution is very stable, and will not show obvious stratification even if after long-term static. Therefore, construction slurry requires different conditioning solutions, and flocculation schemes are different. And the cost of active sludge conditioning is much lower than that of construction slurry conditioning.

Therefore, three kinds of samples including active sludge, river and lake sludge and construction waste slurry were studied for conditioning, flocculation and dehydration experiments. The results are shown in table 2, where PAC, PSAF, APAM and CPAM are the abbreviations of polyaluminum chloride, polyferric silicate, negative ion polyacrylamide and positive ion polyacrylamide respectively.
The moisture content of the three types of sludge is ideal after dewatering, which proves that this dewatering equipment is feasible, but the air-drying property of active sludge is the worst. The moisture content of construction waste slurry had the lowest value of 29.56% and decreased the most after 2-day static to be of 11.36%. The dewatering rate of construction waste slurry and river and lake sludge after dewatering is ideal under natural air-drying, which is conducive to the later resource recycling utilization.

Table 2. Experimental comparison of conditioning, flocculation and dehydration of different sludge samples

| Samples         | Main ingredients of the conditioner | Flocculant       | MC<sup>a</sup> | MC<sup>b</sup> |
|-----------------|------------------------------------|------------------|----------------|----------------|
| Sludge<sup>1</sup> | metal ion                          | PAC/PSAF+APAM    | 29.56%         | 11.36%         |
| Sludge<sup>2</sup> | Quicklime, wood dust               | CPAM             | 60.66%         | 56.82%         |
| Sludge<sup>3</sup> | Deodorant, heavy metal capture agent | CPAM             | 46.00%         | 33.92%         |

<sup>1</sup>Construction waste slurry. <sup>2</sup>Active sludge self-supporting. <sup>3</sup>River and lake sludge.  
<sup>a</sup>Moisture content of mud cake after press filter dehydration.  
<sup>b</sup>Moisture content of mud cake after 2-day static

4. Conclusion

Combined with the technology and slurry characteristics, the complete equipment for sand separation and sand cleaning, mud conditioning and flocculation, mud concentration and dehydration and drainage depth purification has been developed, forming a complete system equipment solution. Slurry contains a lot of sand and gravel. Using excellent high-efficient sand separation and sand cleaning equipment, the separated sand and gravel can meet the recycling of resources. Construction slurry mostly contains dispersants and has a small particle size, so the conditioners must contain metal ions. The moisture content of slurry is higher. The sludge moisture content after the separation can be less than 30% with the solid-liquid separation technology, according with the requirement of resource utilization, and water isolated reaches discharge standards (usually need to conform to the law of the People's Republic of China on integrated wastewater discharge standard "(GB8978-1996) in the secondary emission standard) or reuse water standard. Because the use amount of building materials is large, the sludge after dewatering is used as building materials, such as making brick, which can solve the problem of resource utilization of sludge effectively and have better economic benefit. Compared with other sludge experiments, mud cakes treated with construction waste slurry have better air-drying speed, water content decreases rapidly, and the environmental protection goal of reduction and resource recycling is achieved.

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References

[1] Wei, Y.B., Chen, L.X., Fan, M.Q., etc. (2016) Experimental study on construction waste slurry treatment by chemical curing method, China Harbour Engineering, 36(4): 26-29.
[2] Niu, J.W. (2017) The application of construction mud treatment technology in a engineering. Shanxi Architecture, 43(12): 193-194.
[3] Liang, Z.S., Yang, C.Q., Gao, H.Y., etc. (2016) Experimental study on rapid separation between water and slurry from construction engineering. Journal of southeast university (Natural Science Edition), 46(2): 427-433
[4] Xu, P.P. (2015) Study on high efficiency and comprehensive dehydration on technique of construction mud, Southeast University, Nanjing.
[5] Sloan, D.S., Pelletier, R.A., Lothrop, T.L. A comparison of sludge dewatering methods: A high tech demonstration project[R]. WEFTEC, 2002, session 82.
[6] Wang, X. (2013) Condition technology for sludge dewatering of construction slurry in N city. HIT Shenzhen graduate school of Harbin institute of technology, Shenzhen.