# Innovative Perspective on IE Tools for Construction Project by Technique Development Improvement

Luoer Liao
Hunan Vocational College of Modern Logistics, Changsha 410001, China
liaoluoer@126.com

**Abstract.** This research is going to introduce a Reservoir Project named as Grass-Land protection which is situated in the lower reaches of Yangtze River, to the north of Channing Island with innovative techniques development which consists of 3 parts such as Engineering Design, site construction and pump station establishment. The IE tools would be used creatively in Rotary Churning Pile technology during the whole process as well as methods of IE tools that are used in the item to improve labor resources efficiency and materials utilization and then to make a comparison between standard technologies and "IE" improved ones. The benefits of technique improvement with IE tools aim at developing efficiency and reducing operating costs especially shortening the duration of the project.

**Keywords:** innovative perspective; IE tools; technique development.

## 1. Description of Construction Technique in Reservoir Project

As is known that Rotary Churning Pile a regular technique being used through rig installation in the grouting pipe (single tube) at the bottom of ground with a special nozzle, when reaching to the expected deepness, the high pressure mud pump and other sections begin to activate at the level of 2Mpa pressure, then the slurry from the nozzle jetting out to fill the interspace of the soil, and slurry and the slack soil are beginning to mix up with together. After a while, the mixed slurry can be adhesive to reform a shape of soil body itself. And the Japanese standard called this technique is CCP. In this project, the required height of water-stop curtain is -15.0m to +8.0m, and comprehensive stress for main body is no less than 2.5Mpa and hydraulic conductivity is 9.5 to 6 cm/s.

### 1.1 Standard Double Row of Single-Tube Construction Technique

According to this conventional technology, the drilling speed is up to 22 cm/min, and the operation efficiency is 12.7 m/hour, however, to considerate comprehensive factors, for instance, depreciation, shifting damage, machinery maintenance and others, the actual working period is about 14.38 hours/day, so that daily equipment productivity is 173.2 m/d. With the real condition of designing layout of this cofferdam, which is able to accommodate for 8 sets of drilling equipment at the same operative space. As consequences, the theory of minimum time for water-stop curtain are almost 22.89(m/pile) x 4032 (pile) / 173.2 (m/d) / 8 (set) = 65.46 days. Consider other factors, with the unpredictable influences on operative period would last for more than 90 days. And the main construction period for this project must be finished in 28 months with a short span of six months for a stage earthwork construction and flood control structure. Because principal part of the project starts later than others, so the entire project progress would be slower, and the structure of sluice foundation treatment and construction duration would be only three and a half months all, in addition, geographic condition is poor as well, on the other hand, construction organization and safety management are extremely too hard to guarantee complete the structure in expected period. The original design of rotary churning pile, diameter of pile is Φ 600mm, interval distance is 500mm and the row spacing is 4m.

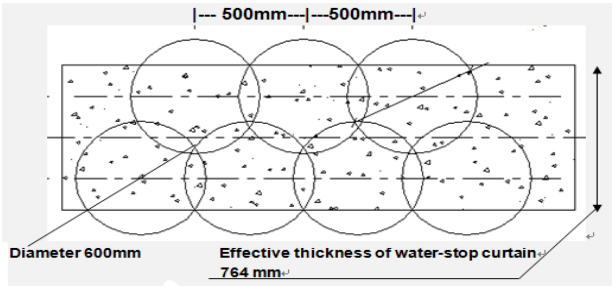


Fig. 1 Double row of single-tube method

### 1.2 Innovative Single Row of Double-Tube Construction Technique

According to Double tube method that speed is up to#10 cm/min, the operation efficiency is#6 m/hour, however, to take comprehensive factors into consideration, such as rod, shifting, the damage for machine, maintenance and other factors, actual working time is about 14.4 hours/day, so that daily equipment productivity is 86.4 m/d. The actual design of the cofferdam area is also only suitable for 8 sets of equipment at the same time. Therefore, the theory of minimum time for water-stop curtain is 23 (m/pile) x 1120 (pile) / 86.4 (m/d) / 8(set) = 38 days, considering the weather, cement supply condition, etc. The influence of unpredictable factors, the actual rotary spray operation period is about#51 d. This main construction period and project must be completed in#27 months and a short span of six months for a stage earthwork construction and flood control structure. Considering the double row of single tube solution has large quantities, the tight for construction period, high technical requirements. The Single row of Double tube solution using the pile diameter Φ1200 mm, interval distance is 900mm, and a total of 1120 piles which sharply reduces quantities and tense of construction period obviously.

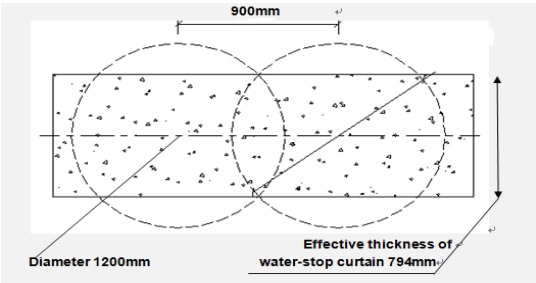


Fig. 2 Single row of double-tube method

## 2. Overall Comparison between Standard and Innovative Methods

### 2.1 Time Measurement.

For standard method, this item of work needs to be done with 4032 piles and at most 8 sets of engineering machines which can be existed in the site for working at the same time because of the condition in construction area. As is known to all, the efficiency for one Rotary Spray Machine (RSM) is 12m/hour. With calculation is 24hrs/@60 Rating=24×60/100=14.4hours. The actual working hours for one machine are 14.4 hours/day. The productivity of one machine=12m/h×14.4 hrs./d=172.8m/d the average length of pile is 23 m/pile, the total quantity is 4032 piles. And the total period is 92.874/(172.8×8) =67 day. Moreover, to take the condition of weather, material supplying and the other negative factors, that actual period of water-stop curtain item is at least 90 days.

Speaking of innovative method, this item of work is totally different, for instance, 24hrs/@60 Rating=24×60/100=14.4hours, actual working hours for one machine is 14.4 hours/day, productivity of one machine=6m/h×14.4 hrs/d=86.4m/d, average length of pile is 23 m/pile, the total quantity is 1120 piles, total length is 23m/pile×1120 piles=25,760 m, and the total period is 25,760/(86.4×8)=38 days. Comparing to Standard Method, almost half of period is shortened.

### 2.2 Cost Analysis

As for standard method, it requires to be a 24 hours' continuous work. In the Water-stop curtain item, it needs 3 shifts for manpower and 8 sets of machines in the construction site. Each set of machine includes 2 kinds of machine, Drilling Machine (DM) and Rotary Spraying Machine (RSM).

Each DM requires 2 qualified operation workers and 3 qualified operation workers for each RSM. The daily wage for a qualified worker is ￥140 per day. The cost for manpower is (2+3) × 3 × 8 × 140 = ￥16800/day.The total expense for manpower is 16800 × 90 days=￥1,512,000, and the cost for machinery items include 8 sets of machine for Water-Stop curtain item is ￥4,320,000, the expense for material in Water-Stop curtain, the total Cement Content is 270 kg/m×23 m/pile×4032 piles=25,038t, the total cost of cement is 350/t×25038=￥8,763,000 and the total expense is 1512000+4320000+8763000=￥14,595,000.

On the other hand, the cost for manpower is (3+4) ×3× 8 × 140 = ￥23,520/day, the total expense for manpower is 23520×51 days=￥1,199,520, the total cost of 8 sets of machine for Water-Stop curtain item is ￥2,856,000, as the expense for material in Water-Stop curtain, the total cement content is 580 kg/m×23 m/pile×1120 piles=14,940t, the total cost of cement is 350/t×14940=￥5,229,000 and the total expense is 1,199,520+2,856,000+5,229,000=￥9,284,520.

## 3. Critical Analysis for Innovative Techniques in this Project

There are problems of the maintenance for equipment's are not processed on time, and lack of emergency spared devices in construction area ubiquitous, especially in peak time, if some drilling machines are in mechanical failure, part of work would be paused until they are repaired completely, anyway it hinders the planned date for each item of project. As a result, it would badly affect the follow-up works.

For the workers, their equipment's are in low use ratio, for example, each set only needs 1 or 2 manual drills, however, it could be found that every worker has one in their hands to create waste at last, moreover, it increases the labour burden for each worker to equip with such a heavy tool. Another point is that the distance between the equipment repair location and construction is a little bit far, when the equipment's are repaired, it costs too much time to transport them to site, actually we can make full use of the room of steel processing area next to the site which would decrease lots of time in the end. About the equipment type, for my perspective, we could select better compatibility ones to replace present equipment's to improve the replacement rate for all, which could be high cost-effectiveness and time-effectiveness. The most serious problem is that almost all machines in the area are overloaded operated to meet tight deadlines, which is very dangerous for safety of workers and harmful for machinery life. As it observed in the area, different shift of workers does not care the condition of machines from the last shift, all machines are nearly working for whole day without any rest and basic maintenance until they are out of order.

In the process of High-pressure rotary jet grouting, the operation code has not clearly defined operation process by the method of Double-tube jet grouting, if it is about to be done by the standard operation design, it might have some potential problems. In the original design, almost all the procedures are made according to the Single-tube method as its background, so some of procedures should be developed to match the Double-tube method. For example, in the standard design, the air compressor and high-pressure pump could be activated at the same time, but if it is going to be done in the Double-tube design, it might cause serious damage to the equipment. Another point is there is no need air supply into the drilling hole when the high-pressure pump starts by the Single-tube design, but it cannot work out in the Double-tube background. In Double-tube method, the air pressure in 2 tubes should be high enough. After that, it can be filled with water then.

## 4. Potential Laboring Risks in Adpating New Technique

In my opinion, no matter which reason happens, the result will be out of plan. Intensive labour workers have to bear the heavy burden daily, long monotonous bending action is easy to make the waist and back muscle fatigue to lead workers cannot complete their jobs effectively, the more serious is about psychology for operating workers, as is known to all, long-period labour actions will easily lead them to low condition and the work cannot be done in schedule, it might cause the delay of the project and a massive loss for the cost of construction. As a result of that, it is obvious to make us enhance the protection for both sides for the workers. And, the original reason for the potentially dangerous conditions to site workers is the limited safety education and lack of effective supervision in the construction site. For this case, we should deal with it from the original source and establish reward and punishment measures to cooperate to perform that. Actually, we should take control at the beginning, all the site workers before employment must pass the operating safety examination to get the certificate we release, and before the tests, all the recruits must be trained together to accept our professional safety education, when they are ready, they can work on the stations. Another reason for that is no professional safety supervisors in the site, in fact, in the company system, the civil engineers are in charge of everything in the site including the safety issues, however, they are too busy to give a special hand to concentrate on the safety conditions, in my opinion, we should establish 2 new professional posts, the safety operating educators and site safety supervisors, moreover, the responsibilities of SSS should be strictly following the reward and punishment measures we establish and make detailed records for each set of operating workers all day long.

As is known to all, the importance for working condition comes at a vital place in our system. Good working environment and an effective pre-arranged planning are requirements of working quality. Because the natural environment, operating equipment’s, environmental sanitation, etc., which are emotions can affect employee's working mental state. Working in the environment of high and good quality grade, the staff's working behavior and working attitude will involuntarily switch to the development of "high-grade" in the end. The second, a good pre-arranged planning is good to control the unnecessary lose in the whole system. We should put the interests of the workers at the first place.

It appeared that some inappropriate phenomenon in machinery maintenance segment. We could take some measures to improve the management to decrease lose and unnecessary damage. Firstly, we should create a position setting system. In this system, each set of machines and equipment’s must be a clear division work to specific workers, for that, it could confirm each worker’s duties. However, the pre-condition is a well-organized reward-punishment system as background. The workers must obey the rules to manage the machines and equipment’s they are offered, if they break the rules, the relevant punishment should be given to specific workers, on the other hand, if they completely obey the rules to manage the things, they could acquire the rewards they deserve. In this method, not only it can improve each worker’s responsibility, but also the safety level. Secondly, all the operators should be professional trained before operating, they must pass the professional operating examinations, which would raise their awareness for standard operations. Thirdly, the distance between the repairing station and site is relative too far, so we can build up a temporary repairing station in the steel processing area next to the site, which could make full use of the room of this area. The last, in the beginning of this item, we should select the well-replaced equipment’s, moreover, the safety supervisors should inspect timely the phenomenon of overload situation.

For the Double-tube high-pressure rotary jet grouting, the air compressor should be activated first for a while. After it is properly functioning, then the high-pressure pump could start. At the same time, air supply and water could be filling in the drilling hole, when the air volume and pump pressure gradually increase to the specified value, then start the grouting pump to send water into the hole. When the pump pressure reaches at normal level, the grouting pump suction can be switched to the slurry storage to start to grout.

# 5. Summary

## 5.1 To Establish Preventive Measures of Climate and Weather Mutation

The rainy season construction flood safety emergency plan should be established, and when the rainy season comes, construction site drainage facilities should be checked, repaired and improved, moreover, in rainy season, to prevent power leakage for machinery electrical equipment by regular inspection. In high temperature season, the heat drugs should be offered on time at site, setting up sun protection facilities in the workplace, adjusting reasonable working time to avoid high temperature period and ventilation cooling measures should be arranged in the field. The last, for inflammable and explosive goods storage should avoid high temperature and direct sunlight. According to construction requirement, lighting equipment should be installed by rule in the construction site and warning signs need to be placed in the right point to avoid night light directly illuminating workers. In restricted visibility period, all works should be prohibited. Ground of anti-skid measures should be taken regularly in winter construction, in construction site, snow and ice should be timely cleaned and the supervisors should check the stability of the machines again.

## 5.2 To Establish Strict Hygiene Inspection for Working and Living Condition

Processing waste, food waste and leftovers are forbidding to pour into the sewer, the underground tunnel should be cleaned by specialized personnel regularly. It is forbidden to dump chemicals in water pipe directly, including the oil or other contaminants. Through a setting truck cleaning gutters and sedimentation tank, waste water could be pouring into the municipal sewage pipe finally. The classification system of the construction waste should be built up, which consist of non-toxic recyclable class and non-toxic not recyclable class, the other is poisonous and harmful class. Strictly control the motor vehicle number at site to limit the exhaust emission control. It requires supervision commissioners to control the noise level in any period.

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