LAN KAI, YAN TAINING, SHAO CHUN
China University of Geosciences

SOME TOPICS ON USING ULTRASONIC METHOD FOR CONCRETE CASTING LEVEL MEASUREMENT IN BORED PILE FOUNDATION

With the high-speed increase of Chinese economy, bored piles are widely used in infrastructure construction projects. But how to gain the exact surface of the casting concrete is a difficult problem in quality control for bored pile. In practice, the only way to avoid quality problems is to cast more volume of concrete, this makes a great waste and gives great pressure on environment for the discard concrete columns. So, develop an ultrasonic device to measure the concrete casting level is of vital importance. Based on analysis the negative impacts by casting too much concrete, the paper presents the design scheme for the device, introduces the main difficulties and summarizes the main up-to-date gains by our group.

В связи с быстрым развитием китайской экономики, бетон широко используется в строительстве инфраструктуры, в частности в виде столбов. Но точное знание глубины заливки бетона в скважину при бетонировании является трудной проблемой. Во избежание аварий столба в скважину часто заливают больше бетона, чем следует. В этом случае не только растет расход бетона, но отходы бракованного столба наносят огромный вред окружающей среде. Поэтому внедрение устройства, основанного на сверхзвуковом принципе, для измерения уровня бетона в процессе бетонирования имеет важное значение. На основе анализа отрицательных воздействий перерасхода бетона автор предлагает проект сверхзвукового устройства, анализирует его недостатки и преимущества.

With the development of economy in China, bored piles are widely used in high-rising building, irrigation and electric power, road and bridge, and geological hazards mitigation projects. To ensure the quality of the shaft, concrete are always casting to the level higher than the cut-level, and then the surpass parts are cut off. Usually the pile head is beneath the ground, it is difficult to know the exact level of the surface of concrete because of the existence of a layer of mud deposit caused by the drilling fluid spreading the whole drilled hole during the casting process using underwater concrete casting technique (Fig.1). In practice, if the concrete casting level surpasses the designed cut-off level too much, the cost including concrete and the other related wastes would increase conspicuously; in contrast, if the level is beneath the designed level, quality problem would occur which may make mitigation and remediation measures necessary, or the shaft would be discarded as useless. This induces a practical method for pile installation that is elevating the in-situ concrete casting level.

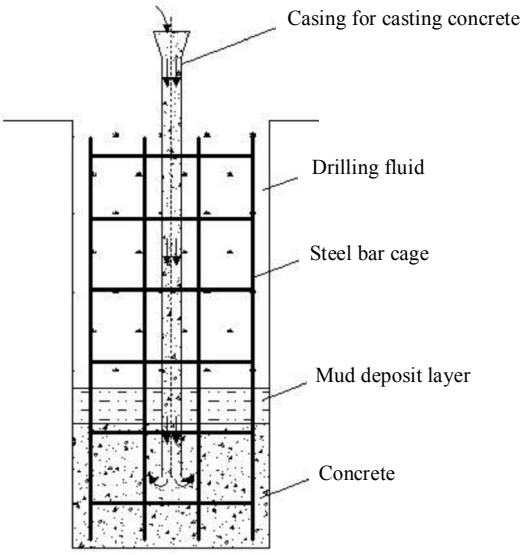


Fig.1. Underwater casting sketch map

'Casting too much concrete problem' exists nearly in every pile foundation project, the surpass height ranges from 0,5 m to 2,0 m. In this case, the waste concrete would be as much as thousands of cubic meters which make the cost rise to billions Yuan (RMB) for an average pile foundation project in China (Table 1). Take the pile foundation project for Shenzhen Golden Centre Business Building for an example. It adopted the largest diameter pile in civil construction in China which is Φ2,8 m for the shaft and Φ3,2 m for the under-reamed tip. The total calculated volume for concrete was 13000 m^3, but the practical installation shows that nearly 400000 Yuan were accounted for casting too much concrete which including the waste of concrete what is about 100000 Yuan and the related cutting off cost and transportation of discard columns. If we take all the pile foundation projects in China into consideration, the cost would be incredible.

So, develop an ultrasonic device to measure the concrete casting level is of vital importance and is consistence to construct an economic and environmental society.

Table 1

Statistic of surpass concrete volume for some projects, from Shao Chun (2006)

Project Name	Floors	Diameter, mm	Length, m	Pile Quantity	Surpass Height, m	Surpass Volume for Single Pile, m^3	Total Surpass Volume, m^3
Taihe Plaza	46	1000	53	694	1,6	1,26	872
Wuhan Plaza	55	1000	59	557	1,5	1,18	656
Jiali Plaza	55	1200	79	440	1,6	1,81	796
Jintian Mansion	20	1000	48	309	1,8	1,41	437
Shenghe Mansion	29	1000	50	285	1,9	1,48	434

Main technical scheme.

Main Index for Designed Device. Maximum Measure Distance 20 m. Measurement Error ≤ 0,2 m.

Overall Scheme. Yan Taining, et al [2] had tried to use an Ultrasonic Fish Detector made by Russia to analyze the ultrasonic propagation in drilling fluid, but the results were not satisfied. Based on those experiments, the overall scheme was presented as Fig.2. It mainly includes three parts, namely, transducing-receiving module, signal modulating module and micro-controller module. Transducing-receiving module is composed of ultrasonic sensors, amplitude magnifying circuit, pulse stimulating circuit and receiving module. Wave filtering, rectifier and magnifying circuit constitute the signal modulating module. The micro-controller module is used for A/D conversion, program controller, data display and communication.

Measurement Theory. Echo method is used in this device. The measurement theory is that when ultrasonic sensors transduce ultra-

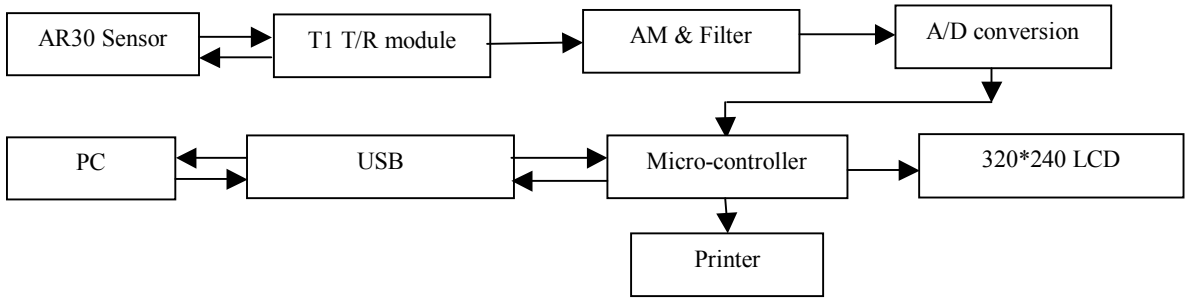


Fig.2. Overall Schematic drawing

sonic, the wave will partly be reflected on the surface of the target, the echo wave will be received by the sensors; Find out the lag time t between transducing and receiving signals, if the propagating velocity C is known, the distance h can be calculated as $h = 0{,}5tC$. In the formula, h is the distance from the concrete level to the sensors, C is the velocity for ultrasonic propagating in drilling fluid, and t is the propagation time in the drilling fluid.

Key problems.

1. For concrete casting level measurement in bored pile installation, ultrasonic should travel in drilling fluids whose characters are different to water and air, but until now, no literature as we know, gave an systematic analysis for ultrasonic wave propagation in drilling fluid. Optimum ultrasonic frequency and transducing energy should be decided according to experiments and this is a time-consuming process because of the diversity of drilling fluids and other relating factors.

2. During the pile installation process, although the characters between drilling fluid and concrete mortar is sharply different, the concrete casting level cannot be easily recognized because of the existence of the mud deposit layer intrinsically caused by the casting technique. This deposit layer can decrease the reflecting energy and confuse the exact target level.

3. When operating the device, the sensor can only be placed in the narrow annular space formed by the casing and bored-hole. This makes disturbance signals difficult to be filtering.

Preliminary results and work in the next step. Until now, our group has completed the elementary circuits and signal processing software. The preliminary results presents as Table 2. In the next step, the study for ultrasonic wave propagation in drilling fluid and the device calibration experiments would be finished in the near months.

Table 2

Preliminary measure results

Measure method	Measure Sequence									
	1	2	3	4	5	6	7	8	9	10
	Depth (m)									
Measure rope	8,5	8,2	8,0	7,8	7,5	7,2	7,0	6,7	6,5	6,3
The device	8,75	8,53	8,28	8,06	7,81	7,43	7,26	7,05	6,79	6,58

REFERENCE

1. *Shao Chun*. Research on remote measuring the altitude of concrete's surface in bored piles by using ultrasonic method [D]. PhD dissertation for China University of Geosciences. 2006.

2. *Yan Taining, Г.А.Григашкин, Zhang Tao*. Portable ultrasonic wave water depth measuring apparatus [R]. China University of Geosciences. 2003.

3. *Zhang Hesheng, Song Mingyao*. Research and development the instrument of ultrasound distance measurement in vehicle [J]. Instrumentation & Sensors, 2003(2), 26-28.