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Testing of Concrete Structures with Non-Destructive Test Method (NDT) Using Ultrasonic Pulse Velocity (UPV) at the Building on the Ancol Beach

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ABSTRACT

The UPV test procedure with the PUNDIT device is set based on the concept of the wave flow speed passing through a solid object bound to the elastic properties of a tangible medium. When used properly and correctly, this tool will provide a lot of information about the condition of the surface or the inside of the concrete. Classification for pulse velocity results according to the speed criteria of concrete quality presented in BS 1881: Section 203:1986 as follows: 4500 m/s = excellent concrete condition, 3400 – 4500 m/s = good concrete conditions, 3000-3500 m/s = medium concrete situation, < 3000 m/ s = concrete problem condition (doubtful concrete condition). The pulse velocity test results are measured by three methods: direct transmission, semi-direct transmission and indirect or surface transmission. The test results for the structure of the beams, cylinders, tie beams, and floor plates of the office building on the edge of the anchor showed that it is in medium concrete condition. The average value of the estimated quality of concrete results of the test UPV Pundit for Beams was 25,29MPa, Slabs was 25,17MPa, Tie Beam was 25,06MPa, and Pilecap was 25,46MPa. The result has met the minimum requirement for concrete solid pressure of 21MPa for the quality of unique structures concrete according to SNI-2847-2019.

Keywords: *Concrete; Structure; UPV Test; Building.*

INTRODUCTION

Indonesia lies at the encounter of four major tectonic plates, namely: 1) the Pacific Plate, 2) the Eurasian Plate, 3) the Indian-Australian Ocean Plate, and 4) the Philippine Plate. The natural disasters in Indonesia are very closely related to the tectonic conditions of Indonesia. However, geodynamic activity only occurs on the edges of the plate, which causes the present Earth configuration and explains the phenomena of terrestrial disasters, as well as affecting ocean and atmospheric disasters, such as the composition of continents and continents [1]. Between 1970 and 2008, 20% of the world's earthquake symptoms occurred in Indonesia. From 2004 to 2008, six major earthquakes and devastating events happened in the Forearc Sumatra region and the South Java region. The quake caused a loss of Rp 60 trillion.

On Monday, November 21, 2022, there was an earthquake with a magnitude of 5.6. The shock was felt in Jakarta and its surroundings. The head of the Meteorological, Climate, and

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Geophysics Agency (BMKG) announced that the center of the earthquake was in Sukabumi District, 10 kilometers southwest of Cianjur District, West Java [2].

Figure 1. Earthquake Center, Sukabumi, Cianjur, West Java

The earthquake caused the majority of officers in the office building to sneak out to anticipate unwanted things. A strong enough earthquake shock can cause damage to buildings; not even a small building can collapse. Therefore, after the occurrence of an earthquake, it is recommended for the owners of buildings, apartments, houses, and others to perform an audit of the structure of the building to evaluate the damaged parts and strengthen the building. In the initial phase, a visual inspection is carried out by looking in detail at each element of the structure of the building affected by the earthquake. Then, a verification is performed using tools so that the results obtained can be measured and validated.

METHODS

The UPV test procedure with the PUNDIT device is set based on the concept of the wave flow speed passing through a solid object bound to the elastic properties of a tangible medium [3]. When used properly and correctly, this tool will provide a lot of information about the condition of the surface or the inside of the concrete. The longitudinal vibration signal generated by the electroacoustic transducer touches the concrete surface to be tested when a signal from a sensor is transmitted across a concrete surface using a contact fluid such as oil paste or cellulose. Concrete experiences a variety of reflections from the material it contains. A complete system to develop voltage waves, including longitudinal waves and slides, which slide through concrete. The first wave captured by the receiver transducer is the longitudinal wave, and the second transducer converts it into an electrical signal.

UPV Pundit tests are conducted according to SNI ASTM C597:2012, BS 1881: Part 203:1986, and ASTM C597-16. This rule explains if the receiver's transducer is able to detect the arrival of early-arrival pulse components [4]. Three methods, among others, can do Pulse Velocity measurement:

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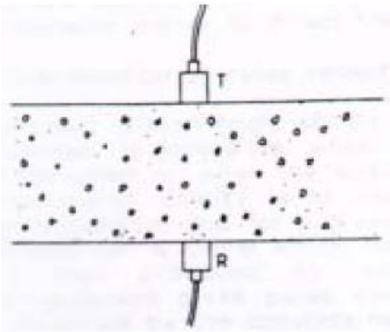
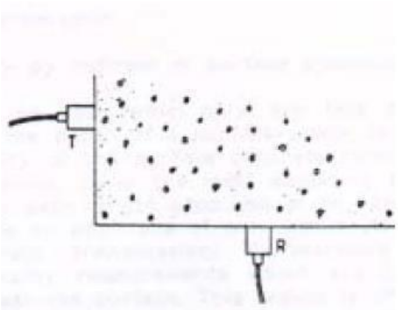
a. Direct transmission



b. Semi-direct transmission



c. Indirect/surface transmission

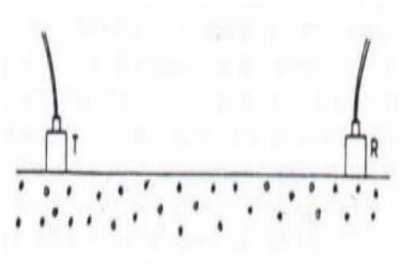


Figure 2. Methods of Pulse Velocity Measurement

Table 1. Assessment Criteria On Ultrasonic Wave Testing

	Pulse Velocity (m/s)	Concrete Conditions
Concrete Quality	> 4500	Excelent
	3500 - 4500	Good
	3000 - 3500	Medium
	< 3000	Doubful

As for the UPV tool parts, the PUNDIT device consists of:
a. UPV Pundit Lab Digital Version
b. Stone Asah Gerinda
c. Calibration instrument
d. Ultrasonic Oil
e. Mister or meter
f. Wire brush

Figure 3. UPV PUNDIT Device

Classification for pulse velocity results according to the speed criteria of concrete quality presented in BS 1881: Section 203:1986 as follows [5] [6]:
a. 4500 m/s = excellent concrete condition
b. 3400 - 4500 M/s= good concrete conditions
c. 3000 - 3500 m / s = medium concrete situation
d. < 3000 m/ s = concrete problem condition (doubtful concrete condition)

The flowchart of the UPV Test Performance is as follows:

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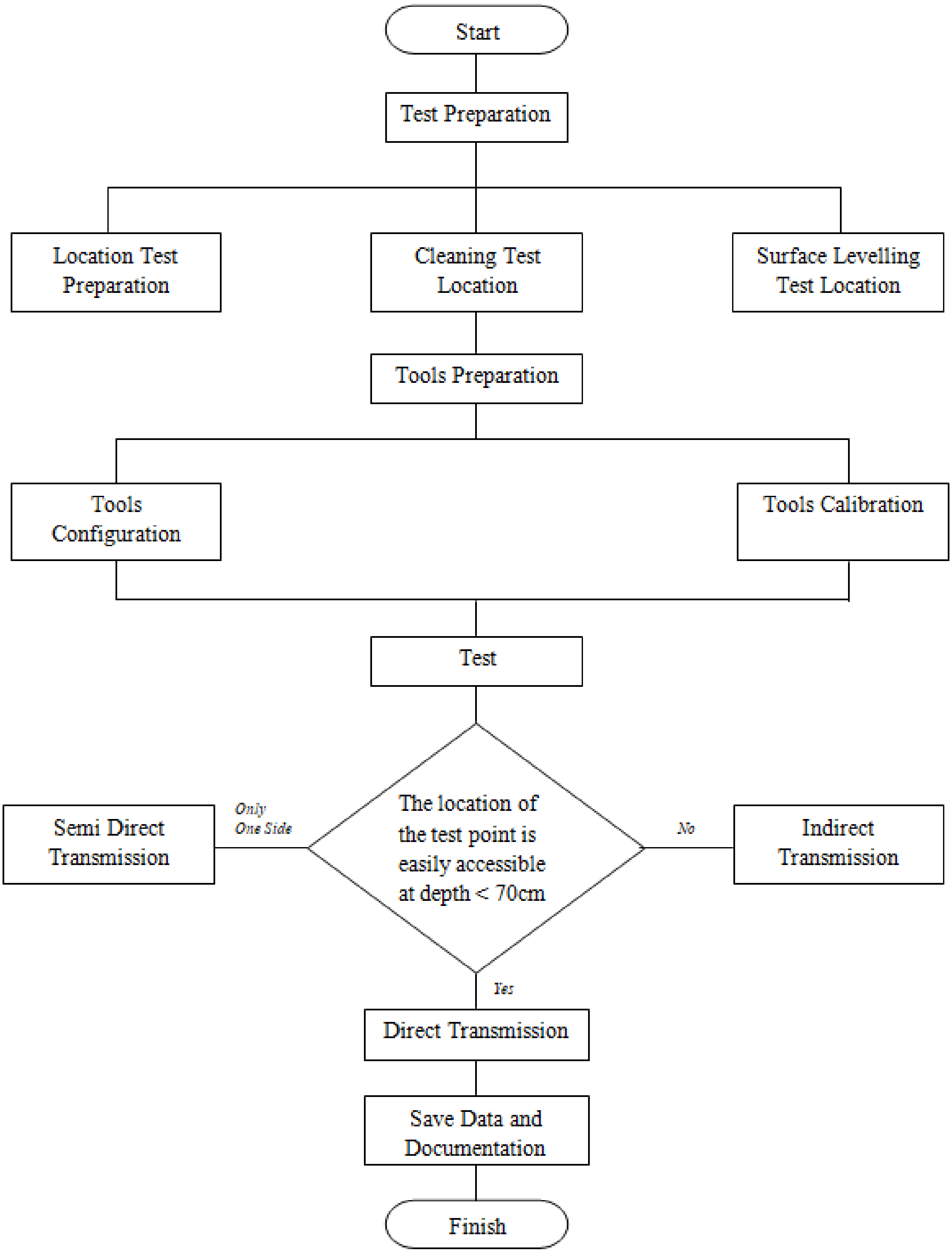

Figure 4. UPV Test Flowchart

The implementation of UPV PUNDIT is divided into three stages, namely [7] [8]:

1. Preparation of the test site.
   This step is an initial preparation for determining and preparing the test point location. The definition of proving ground, for example, is based on the condition of concrete with a relatively good surface. After that, level the surface of the test point with the grinder and mark it with the Pilox. (marking).
2. Preparation of the device

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At this stage, the UPV Pandit device is positioned as required and calibrated according to the calibration instructions of the test object. (lumasi permukaan benda uji dengan gel ultrasound).

3. Testing
   This step is where the pulse velocity is measured with the instrument. After a brief explanation of the standard used, there are three ways to measure pulse. Direct transfer is highly recommended for recording because the results are the most accurate. Still, the limitations of field recording, the results obtained by semi-direct transfer can be said to be very real, and the latter is indirect/surface transfer, which is the method that uses the worst results compared to other methods but must be reduced so that the results approach the pulse values of the direct transmission frequency. Every time you do an inspection, you should apply an ultrasonic gel to the concrete that will be inspected.

RESULT AND DISCUSSION

The test is based on the values generated by the UPV PUNDIT device. The results are then processed to produce, as shown in the picture below.

Measurement Mode	Result	Distance	Velocity	Time 1
Pulse Velocity	3324 m/s	0.100 m	3324 m/s	36.1 µs
Pulse Velocity	2658 m/s	0.200 m	2658 m/s	90.3 µs
Pulse Velocity	3529 m/s	0.100 m	3529 m/s	34.0 µs
Pulse Velocity	2284 m/s	0.200 m	2284 m/s	105.1 µs
Pulse Velocity	2948 m/s	0.100 m	2948 m/s	40.7 µs
Pulse Velocity	3243 m/s	0.200 m	3243 m/s	74.0 µs
Pulse Velocity	2697 m/s	0.100 m	2697 m/s	44.5 µs
Pulse Velocity	3011 m/s	0.200 m	3011 m/s	79.7 µs
Pulse Velocity	3166 m/s	0.100 m	3166 m/s	37.9 µs

Figure 5. Pulse Velocity Test Value

The pulse velocity result cannot be directed and must be processed to produce a value. Replace the indirect coefficient with a direct coefficient by adding the resulting speed to the ASTM C215 Test Method for Transversal, Longitudinal, and Torsional Fundamental Resonance Frequencies of Concrete Specimens based on Guide 11.1.4.4. 5% to 30%. In this case, indirect factor values are assumed to be 10%.

Table 2. Results of Pulse Velocity Calculation with Criteria

No	**ID**	**Test Location**		**Average Direct Velocity**	**>4500 m/s**	**3500-4500 m/s**	**3000-3500 m/s**	**<3000 m/s**	**Description**
	Sample	**Location**	**Type**	**[m/s]**	**Excellent**	**Good**	**Medium**	**Doubtful**	
1	U-1	2nd Floor	Beam	3223	-	-	√	-	Medium Concrete Grade

No	ID Sample	Test Location Location	 Type	Average Direct Velocity [m/s]	>4500 m/s Excellent	3500-4500 m/s Good	3000-3500 m/s Medium	<3000 m/s Doubtful	Description
2	U-2	3rd Floor	Beam	3215	-	-	√	-	Medium Concrete Grade
3	U-3	3rd Floor	Beam	3252	-	-	√	-	Medium Concrete Grade
4	U-4	4th Floor	Beam	3256	-	-	√	-	Medium Concrete Grade
5	U-5	4th Floor	Beam	3175	-	-	√	-	Medium Concrete Grade
6	U-6	5th Floor	Beam	3225	-	-	√	-	Medium Concrete Grade
7	U-7	1st Floor	Pilecap	3230	-	-	√	-	Medium Concrete Grade
8	U-8	1st Floor	Pilecap	3246	-	-	√	-	Medium Concrete Grade
9	U-9	1st Floor	Pilecap	3214	-	-	√	-	Medium Concrete Grade
10	U-10	1st Floor	Tie Beam	3183	-	-	√	-	Medium Concrete Grade
11	U-11	1st Floor	Tie Beam	3255	-	-	√	-	Medium Concrete Grade
12	U-12	1st Floor	Tie Beam	3212	-	-	√	-	Medium Concrete Grade
13	U-13	1st Floor	Slab	3252	-	-	√	-	Medium Concrete Grade
14	U-14	1st Floor	Slab	3174	-	-	√	-	Medium Concrete Grade
15	U-15	1st Floor	Slab	3236	-	-	√	-	Medium Concrete Grade

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From the results above, each element of the structure was subtracted so that the criteria and values of the pulse velocity of each element could be inferred. The results of the velocity above then correlated to the quality of concrete according to the formula based on ASTM C597 - 16 Standard Test Method for Pulse Velocity Through Concrete.

$$V = \sqrt{\frac{E(1-\mu)}{\rho(1+\mu)(1-2\mu)}} \quad (1)$$

Description:
E = dynamic modulus of elasticity
μ = dynamic Poisson's ratio
ρ = density.
Here is a tabulation of the correlation of concrete quality with concrete pulse velocity.

Table 3. Calculation of the Correlation of Concrete Quality Pulse Velocity

No	**ID Sample**	**Element of Structure**		**Direct Velocity Pulse**	**Poisson Ratio**	**Density (Kg/m3)**	**Ec (Mpa)**	**fc' MPa**
		Location	**Type**					
1	U-1	2nd Floor	Beam	3223	0,15	2400	23607,77	25,23
2	U-2	3rd Floor	Beam	3215	0,15	2400	23496,55	24,99
3	U-3	3rd Floor	Beam	3252	0,15	2400	24031,59	26,14
4	U-4	4th Floor	Beam	3256	0,15	2400	24096,67	26,29
5	U-5	4th Floor	Beam	3175	0,15	2400	22919,60	23,78
6	U-6	5th Floor	Beam	3225	0,15	2400	23633,27	25,28
7	U-7	1st Floor	Pilecap	3230	0,15	2400	23713,96	25,46
8	U-8	1st Floor	Pilecap	3246	0,15	2400	23950,36	25,97
9	U-9	1st Floor	Pilecap	3214	0,15	2400	23475,51	24,95
10	U-10	1st Floor	Tie Beam	3183	0,15	2400	23034,07	24,02
11	U-11	1st Floor	Tie Beam	3255	0,15	2400	24083,64	26,26
12	U-12	1st Floor	Tie Beam	3212	0,15	2400	23449,81	24,89
13	U-13	1st Floor	Slab	3252	0,15	2400	24034,84	26,15
14	U-14	1st Floor	Slab	3174	0,15	2400	22891,02	23,72
15	U-15	1st Floor	Slab	3236	0,15	2400	23798,02	25,64

*Based On BS 1881: Part 203: 1986

Average quality of concrete beam = 25,29MPa
Averaging quality concrete plate = 25,17MPa
Average quality of tie beam concrete = 25,06MPa
Average quality cement pile cap = 25,46MPa
This result has met the minimum requirement of concrete solid pressure of 21MPa for the quality of unique structures concrete based on SNI-2847-2019.

CONCLUSION

The pulse velocity test results are measured by three methods: direct transmission, semi-direct transmission and indirect or surface transmission. The test results for the structure of the beams, cylinders, tie beams, and floor plates of the office building on the edge of the anchor showed that it is in medium concrete condition. The average value of the estimated quality of concrete results of the test UPV Pundit for Beams was 25,29MPa, Slabs was 25,17MPa, Tie Beam was 25,06MPa, and Pilecap was 25,46MPa. The result has met the minimum requirement for concrete solid pressure of 21MPa for the quality of unique structures concrete according to SNI-2847-2019.

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