Ujian Tidak Merosakkan (UTMr) terhadap konkrit mengandungi bijih besi

Non destructive Testing (NDT) of concrete containing hematite

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Abstrak

Kertas kerja ini menerangkan keputusan ujian tidak merosakkan ultrasonic dan tukul lantunan terhadap konkrit yang mengandungi bijih besi. Batuan bijh besi (hematite) digunakan sebagai agregat bagi mendapatkan konkrit berketumpatan tinggi untuk kegunaan perisai sinar-X dan gamma. Kubus konkrit bersaiz 150mm mengandungi hematite sebagai agregat kasar disediakan dengan mengubah nisbah campuran, nisbah air/simen dan jenis agregat halus. Semua sampel dirawat dengan merendam dalam air selama 7 hari dan ujian dilakuakn selepas konkrit mencapai umur 28 hari. Ketumpatan, nombor lantunan dan halaju ultrasonik diukur sebelum sampel dimusnahkan melalui ujian mampatan. Keputusan pengukuran diterang dan dibincangkan.

Abstract

This paper described the results of Non-destructive ultrasonic and rebound hammer measurements on concrete containing hematite. Local hematite stones were used as aggregates to produce high density concrete for application in X-and gamma shielding. Concrete cube samples (150mm x 150mm x 150mm) containing hematite as coarse aggregates were prepared by changing mix ratio, water to cement ratio (w/c) and types of fine aggregate. All samples were cured in water for 7 days and then tested after 28 days. Density, rebound number (N) and ultrasonic pulse velocity (UPV) of the samples were taken before compressed to failure. The measurement results are explained and discussed.

Keywords: high density concrete, ultrasonic pulse velocity, density, radiation shielding

INTRODUCTION

Normal concrete is the most common and cheap materials for construction including radiation shielding bunker. Local hematite was used as an aggregate to produce high density concrete. This will provide an alternative to normal concrete, better and effective radiation shielding.

Compression strength is the main parameter check for determining concrete quality. Other than strength, the parameters such as durability, volume stability and impermeability are also important in evaluating the concrete quality. In general, most people think that by increasing the strength means that other parameters are also increased. However, this assumption is not always true. For example, the use of excessive cement will increase the strength but at the same time it also produces shrinkage and creep (Mindness& Young 1981).

For shielding purposes, density is the main parameter concerned. The high the strength normally implies to higher density concrete. But this is also not always true.

The use of NDT in inspecting concrete is not as common as in the metallic construction. This may be due to lack of demand or no specific requirement by code or standard from the related sectors as compared to metallic construction. However, research and development activities in various NDT methods indicate that NDT has a great potential to be applied on concrete structures. Most materials in buildings, bridges, dam, tunnels, etc. are made of concrete. This construction requires concrete of high quality in terms of strength and durability. NDT has the ability to determine the strength and durability of critical construction without damaging them and the test can be carried out on-site.

Ultrasonic method has been used to estimate strength, elastic modulus, slab thickness, crack depth, and to detect voids, lamination and bar location [National Seminar on NDE of concrete, 1991]. It is recognized as the only NDT method available at this time, which is capable of determining the crack depth to a certain degree of reliability. The technique was also used to monitor the mixing materials during construction [Elvery, 1976], determine the concrete uniformity [Tomsett, 1980], thickness measurement and to estimate the depth of damage caused by fire [Tomsett, 1980].

Rebound hammer have been used to estimate strength or surface hardness of the concrete [Pauzi, 1996]. At the moment the only available NDT method for measuring density is by gamma backscatter [Adil, 1977]

The research is carried out to correlate UPV and rebound hammer with the concrete density and elastic property.

METHODOLOGY

Sample Preparation

The concrete containing hematite cubes were prepared based on JKR methods. The block sizesare 150mm x 150mm x 150mm. The workability is medium. The samples were cured by immersion into water for 7 days. The samples were tested at the age of 28 days.

Table 1 show the mix proportion used in the experiment.

Table 1: The mix proportion

Mix	Proportion	W/C	Cement (kg)	Hematite sand (kg)	Crushed hematite (kg)
A	1:1:2	0.5	10	10	20
B	1:1.5:3	0.5	10	15	30
C	1:2:3	0.5	10	20	30
D	1:2:4	0.5	10	20	40
D1	1:2:4	0.7	10	20	40
D2	1:2:4	0.75	10	20	40
D3	1:2:4	0.8	10	20	40
E	1:2:6	0.5	10	20	60
Mix	**Proportion**	**W/C**	**Cement (kg)**	**River sand (kg)**	**Crushed hematite (kg)**
F	1:1:2	0.5	10	10	20
G	1:1.5:3	0.5	10	15	30
H	1:2:3	0.5	10	20	30
I	1:2:4	0.5	10	20	40
I1	1:2:4	0.7	10	20	40
I2	1:2:4	0.75	10	20	40
I3	1:2:4	0.8	10	20	40
J	1:2:6	0.5	10	20	60

Test Procedures

UPV is measured using Ultrasonic Pulse Velocity meter made from TICO with the probe frequency of 50 kHz.The direct transmission technique was used to determine UPV in concrete. Grease was used as couplant between the transducer and concrete surface. The procedure is based on MS EN 12504-4: 2013. Rebound hammer test were conducted as described in MS EN 12504-2: 2013. The density was calculated from measured weight and volume. The volume was determined by water displacement method. All samples were finally compressed to failure using a calibrated compression machine to obtain concrete compressive strength.

RESULTS AND DISCUSSION

Figures 1 and 2 show the correlation between ultrasonic pulse velocity and rebound number with concrete density. It is found that the correlation is poor. However, in general as the density increases, ultrasonic pulse velocity and rebound number are also increased. Ultrasonic pulse velocity and density are maximum for the mix using river sand. For rebound number versus density, the maximum is for the mix using hematite sand. This probably means that concrete with river sand aggregate is more elastic than the one with hematite sand.

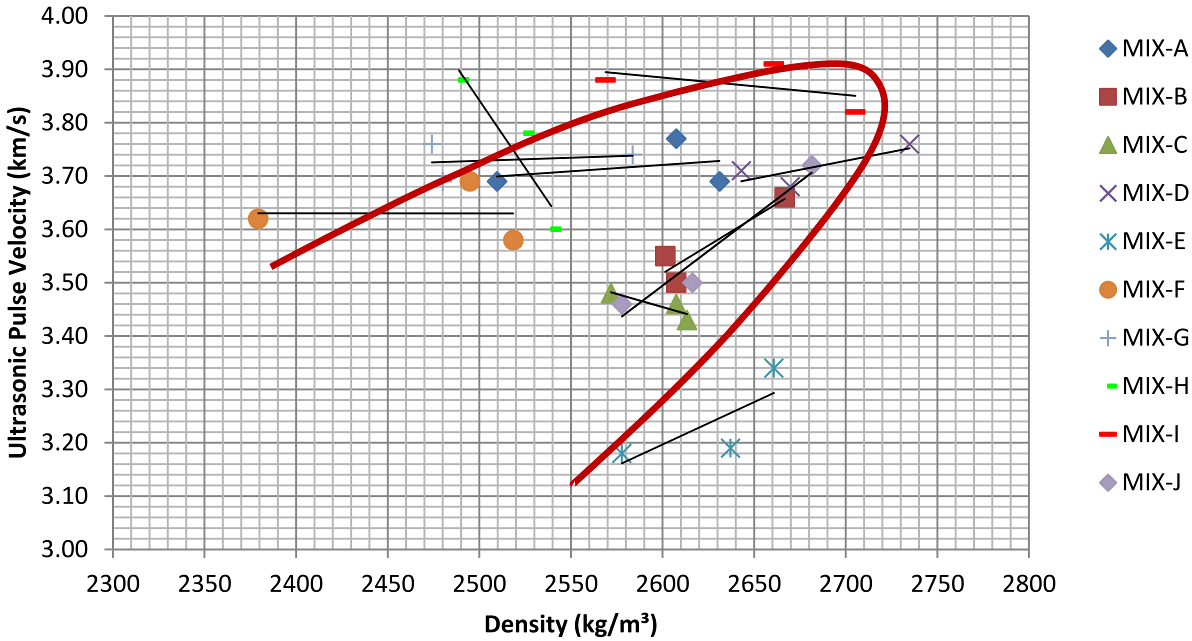

Fig.1: Ultrasonic pulse velocity versus concrete density

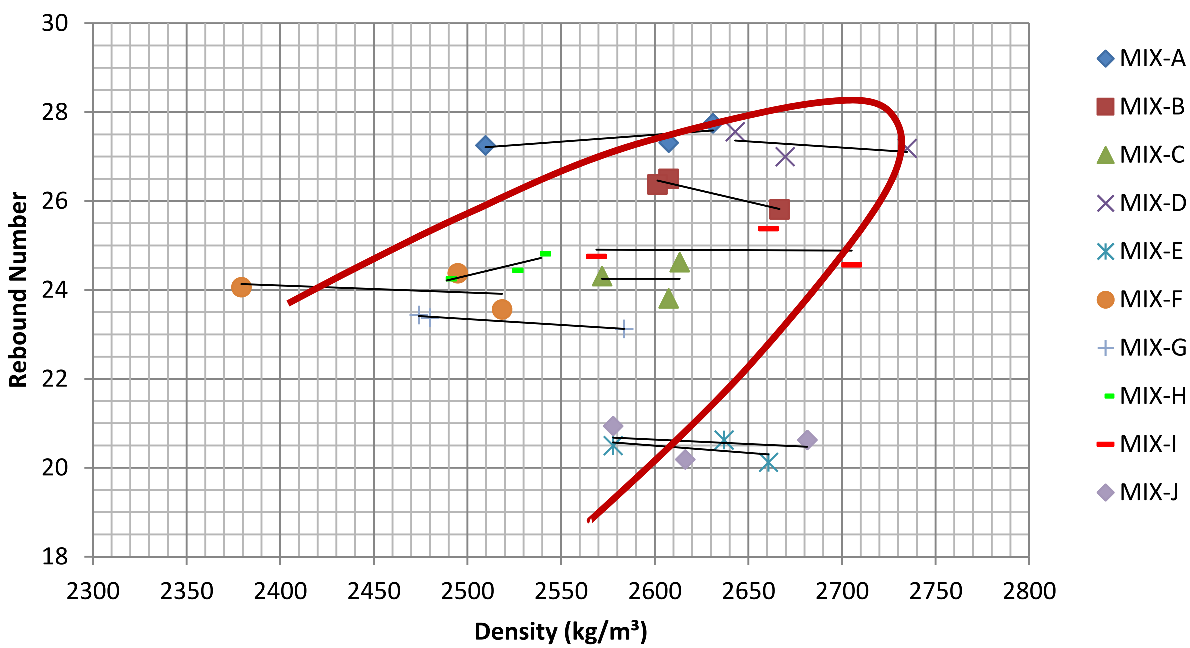

Fig.2: Rebound number versus concrete density

Figures 3 and 4 show the correlation between ultrasonic pulse velocity and rebound number with concrete strength. Both rebound number and pulse velocity increase as the strength is increased.

Mix A with more cement content produces stronger concrete and high rebound number. The pulse velocity versus strength becomes flat at high strength concrete, i.e. little change in velocity as strength increases especially after 28 N/mm^2.

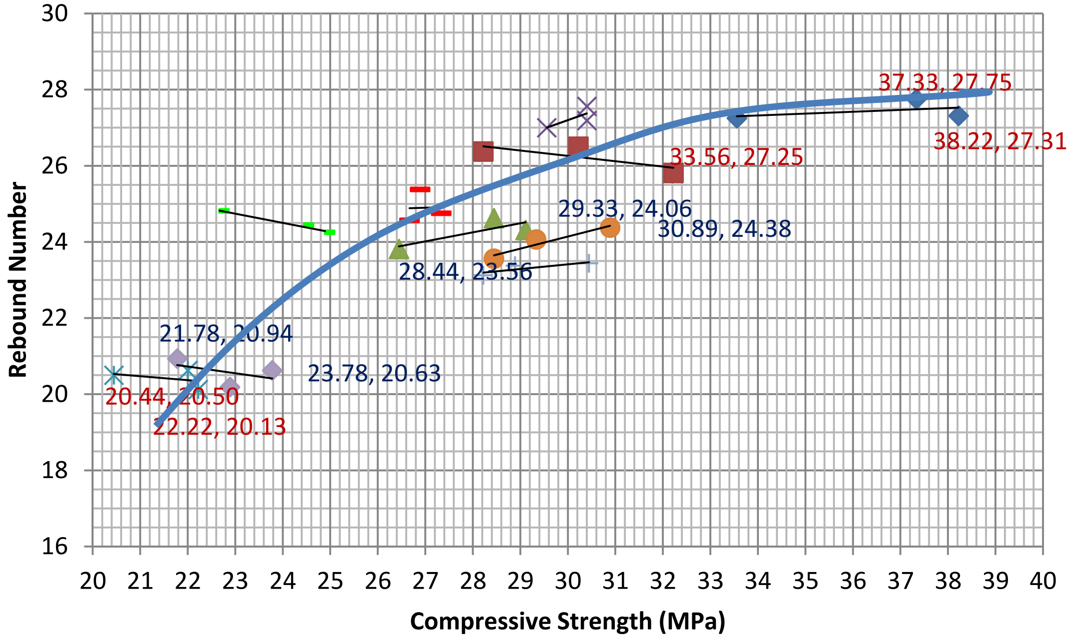

Fig.3: Rebound number versus compressive strength

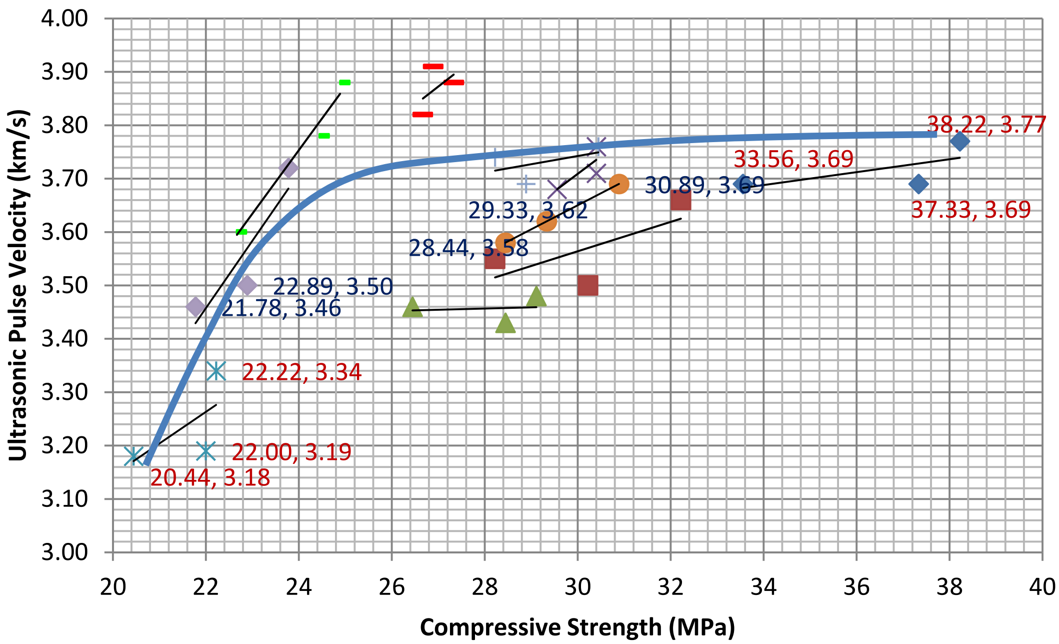

Fig.4: Ultrasonic pulse velocity versus compressive strength

Concrete with hematite sand increase the density and rebound number as compared to river sand (Fig. 5). However the pulse velocity is high for river sand concrete compared to hematite sand

(Fig. 6). From these figures also, high water/cement ratio will reduce rebound number, pulse velocity and density i.e. in general the concrete quality is reduced for high water/cement ratio.

The elastic property of concrete is also good for river sand aggregate and low water/cement ratio (Fig. 7).

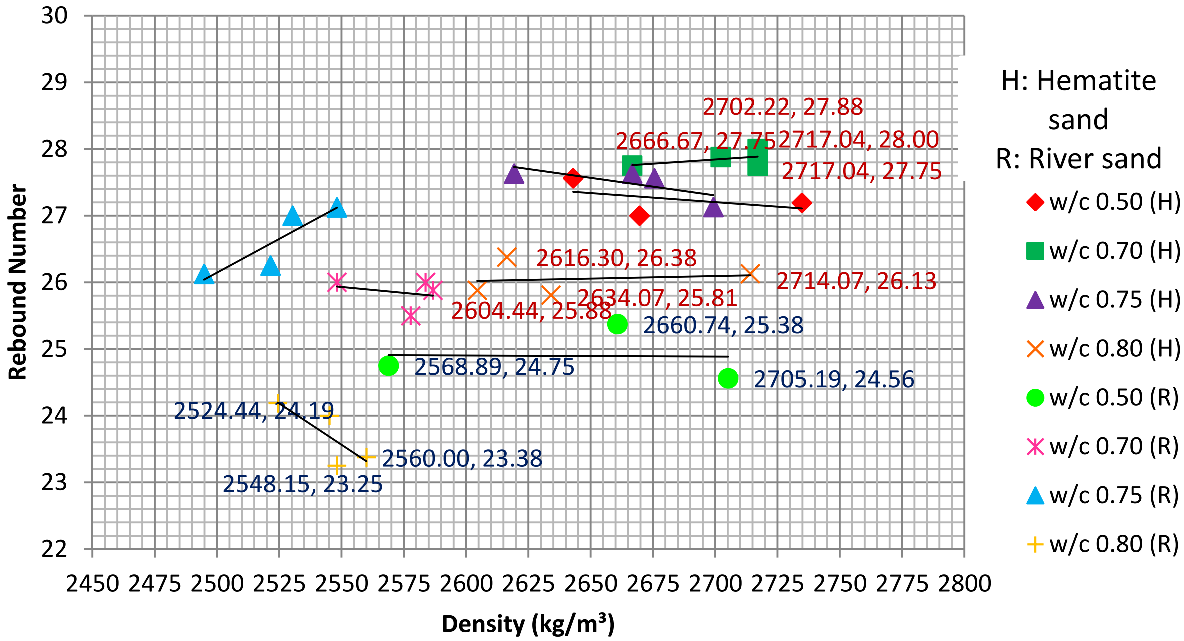

Fig 5: Rebound number versus density

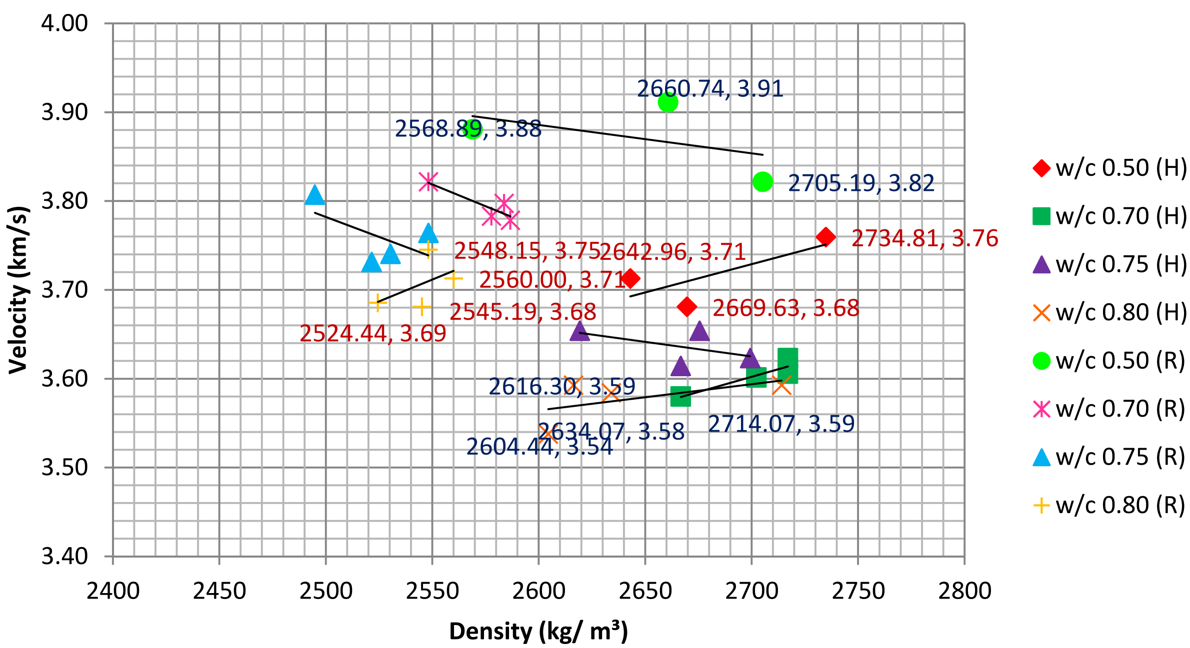

Fig 6: Pulse velocity versus density

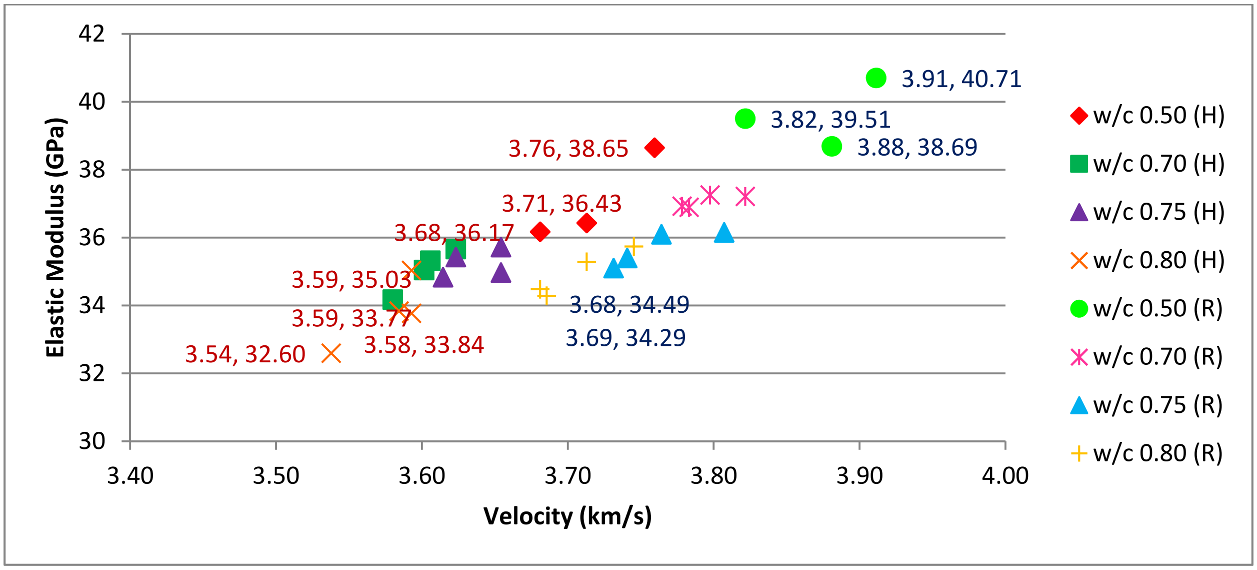

Fig. 7: Elastic modulus versus Pulse velocity

CONCLUSION

The high rebound hammer indicates high strength and high density concrete. The pulse velocity is also increase as strength increases but as the strength increases further the velocity becomes constant. The pulse velocity is actually measure the elastic property of the materials and may be related to durability of the materials. For a good quality the rebound number and pulse velocity should be high.

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