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Estimation Compression Strength of Concrete Made from Local Material Using Non-destructive Tests

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Abstract The research focus on non-destructive testing on an ordinary concrete made of local materials (coarse and fine aggregate) which are obtained from the Jufrah area. Concrete mix design is done by using BRE method with different W/C ratio. Five concrete mixes design are made with different target compressive strength. The target compressive strength for three specimens cube at age 28 days was ranged between (10–60) MPa. Two non-destructive tests were done on the concrete specimens which are Schmidt hammer and Ultrasonic pulse velocity (UPV). Destructive test is conducted on concrete specimens in order to determine the concrete compressive strength, a relationships are obtained between Schmidt Hammer rebound number, Ultrasonic Pulse Velocity and cubes compressive strength of the local concretes.

Keywords: Concrete, Strength, Schmidt Hammer, Ultrasonic pulse velocity, aggregate.

تقدير قوة الضغط للخرسانة مصنوعة من المواد المحلية باستخدام الاختبارات غير الاتلافية

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الملخص يركز البحث على الاختبارات غيرالاتلافية على الخرسانة العادية المصنوعة من المواد المحلية (ركام الخشنة وناعم) من منطقة الجفرة. تم تصميم الخلطة الخرسانية باستخدام طريقة BRE مع نسبة W/C مختلفة. تم تصميم خمس خلطات ذات مقاومة انضغاط مختلفة، وتراوحت مقاومة الانضغاط المستهدفة لثلاثة عينات مكعبية بعد 28 يوما ما بين (10–60) MPa. تم إجراء اثنين من الاختبارات غيرالاتلافية على العينات الخرسانية، مطرقة شميدت وسرعة النبضات بالموجات فوق الصوتية. وتم إجراء اختبار الانضغاط على العينات الخرسانية من أجل تحديد قوة الضغط. وتم الحصول على علاقات بين عدد الارتدادات لمطرقة شميدت، وعلاقات بين سرعة النبضات بالموجات فوق الصوتية وقوة الضغط من الخرسانة المحلية.

الكلمات المفتاحية: الخرسانة، القوة، شميت المطرقة، سرعة النبض بالموجات فوق الصوتية، الركام.

Introduction

It is often necessary to test concrete structures after the concrete has hardened to determine whether the structure is suitable for its designed use. Ideally such testing should be done without damaging the concrete. The tests available for testing concrete range from the completely non-destructive, where there is no damage to the concrete, through those where the concrete surface is slightly damaged, to partially destructive tests, such as core tests and pullout and pull off tests, where the surface has to be repaired after the test.

The range of properties that can be assessed using non-destructive tests and partially destructive tests is quite large and includes such fundamental parameters as density, elastic modulus and strength as well as surface hardness and surface absorption, and reinforcement location, size and distance from the surface. In some cases it is also possible to check the quality of workmanship and structural integrity by the ability to detect voids, cracking and delamination. Non-destructive testing can be applied to both old and new structures. For new structures, the principal applications are likely to be for quality control or the resolution of doubts about the quality of materials or construction. The testing of existing structures is usually related to an assessment of structural integrity or adequacy. In either case, if destructive testing alone is used, for instance, by removing cores for compression testing, the cost of coring and testing may only allow a relatively small number of tests to be carried out on a large structure which may be misleading. Non-destructive testing can be used in those situations as a preliminary to subsequent coring[1,2,3].

Aim, and objectives

The objective of the paper to find a relationship between the compression strength and Schmidt hammer rebound number, also between the compression strength and the Ultrasonic pulse velocity for an ordinary concrete made of local materials coarse and fine aggregate from the Jufrah area.

The Experimental Work

This part describes the properties of materials of concrete mix design, aggregate, cement and water. In addition the mixing, casting, and curing of concrete specimens.

Cement

Portland cement type I 42.5N was used in this study. The cement was supplied by Zliten Factory.

Aggregates

Coarse aggregate

The coarse aggregate used was single graded aggregate comprising crushed with a nominal size ranging from 5 to 20 mm. Sieve analyses were carried out in accordance with BS 882:1992[4], in order to check whether the size distributions of the aggregate satisfy the limits required in the standard.

Sieve analysis of coarse aggregate

The sieve analysis test of aggregates was done on two samples with a nominal maximum size (NMZ) 20 and 10 mm. After the test has been conducting on each size alone, both sizes of aggregate were mixed to improve the mix even though each of them was matching the specifications. The mixing ratio was 50 and the result is shown in figure (1).

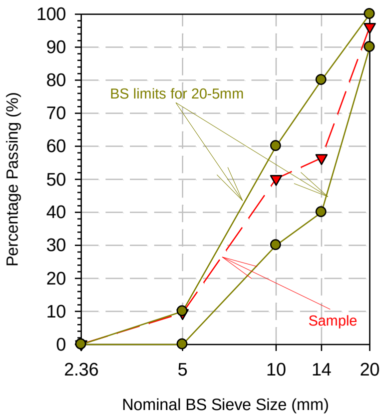

Fig. 1: Grading curve of combined 20-10mm of coarse aggregate to BS 882 :1992

Fine aggregate

Natural sand has been used, the same tests carried out on the coarse aggregate were also undertaken on the fine aggregate.

Sieve analysis of fine aggregate

The sieve analysis test of fine aggregates was done on two samples with different sizes (sand, fine aggregate with size 5mm). Both sizes of aggregate were mixed to improve the mix although each of them was matching the specifications. The mixing ratio was 30% of fine aggregate with size 5mm and 70% of sand. figure (2) shown the combined sand and fine aggregate with size 5mm.

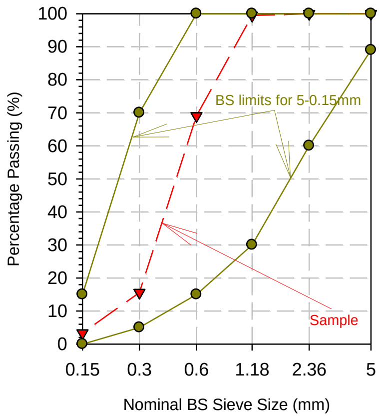

Fig. 2: Grading curve of combined sand and 5mm of aggregate to BS 882 :1992

Water

The quality of concrete mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportion[5]. Therefore , tap water was used throughout the mixing and curing and curing procedures of concrete in this study.

Mixing

All aggregates were premixed with half of the mixing water for about two minutes. Cementitious materials and the remaining mixing water were added and mixing was carried out for about three minutes to ensure concrete was homogeneous[6].

Casting, compaction and curing of specimens.

Concrete mix design is done by using BRE[7] method with different W/C ratio, Before casting of specimens, the steel mold was oiled with a thin oil coat to facilitate separation of specimens. The process of casting and compaction of concrete with some two interrelated and usually implemented at the same time. Casting and compaction are very important to get the high resistance of the concrete and reduce the permeability of concrete and thus longer lifespan for concrete. In this study, the concrete was casted into 150*150*150 mm cube moulds. The concrete is putted on three layers each layer has been compacted by using concrete vibrators to get good compaction process then the surface.

Results and analysis

The compressive strength, rebound number and UPV of hardened concrete

After casting of the three cubes of each mixture and curing for 28 days, Schmidt hammer, Ultrasonic Pulse Velocity and Compressive Strength tests were used to test the cubes at 28 days. In Schmidt hammer (direction of hammer horizontally = 0) 15 points were taken for each cube, the distance between one point and another was 2cm in one face, an average of the reading of the three cubes was taken. The UPV test was done to the three cubes by holding the sensors on each side of cube and recording the transmission time, from it the velocity of waves can be obtained by dividing transmission time by length of the cube, an average for each cube reading and the three cube was done. After all non-destructive tests were done the cubes were tested for compressive strength. The values of the reading are shown in tables 1.

Table 1 Results of the tests

Strength (MPa)	Age (day)	Compression Strength (MPa)	Rebound Number	UPV (km/s)
10	7	17.23	27.76	3.80
		17.91	27.57	4.00
		16.71	28.29	3.89
	14	22.35	27.67	4.05
		23.94	28.58	4.23
		21.89	28.25	4.17
	28	29.11	30.43	4.27
		28.23	29.13	4.44
		27.26	30.93	4.56
20	7	22.41	30.07	4.13
		23.62	30.06	4.05
		22.73	30.81	4.05
	14	27.00	28.88	4.05
		28.49	28.00	4.11
		28.90	27.00	4.17
	28	35.02	31.85	4.25
		33.97	29.64	4.41
		33.33	30.35	4.41
30	7	31.84	35.27	4.44
		34.87	35.00	4.50
		36.33	35.29	4.49
	14	35.87	33.93	4.49
		39.92	32.50	4.23
		40.41	31.87	4.26
	28	45.73	34.35	4.64
		44.56	35.35	4.56
		45.35	39.78	4.57
40	7	49.55	41.65	4.34
		49.41	40.40	4.16
		48.94	41.83	4.53
	14	56.14	36.93	4.72
		55.94	38.75	4.66
		57.36	37.38	4.56
	28	57.13	40.07	4.36
		58.94	41.71	4.67
		59.38	43.14	4.82
50	7	46.42	37.25	4.29
		46.48	35.64	4.17
		49.32	34.13	4.20
	14	51.42	40.50	4.57
		53.01	37.56	4.55
		52.20	36.46	4.49
	28	59.99	38.51	4.70
		59.54	39.80	4.70
		57.28	40.31	4.67
60	7	51.44	37.00	4.23
		54.11	39.14	4.11
		53.15	37.70	4.18
	14	59.00	38.80	4.44
		61.00	39.00	4.57
		62.00	38.18	4.69
	28	68.30	42.38	4.81
		68.90	43.18	4.73
		67.11	41.13	4.72

Relationship between cube Compression strength and Schmidt hammer rebound Number:

The compression strength and Schmidt hammer rebound Number relationship are shown in figure 3. using different equations to fit the data. Based on the correlation factor (R^2) shown in table (2) obtained from the best curve fit the data. Polynomial second order fit the data quite well is. However what should be used for the hummer is linear equation that has R^2 equal to 0.8958.

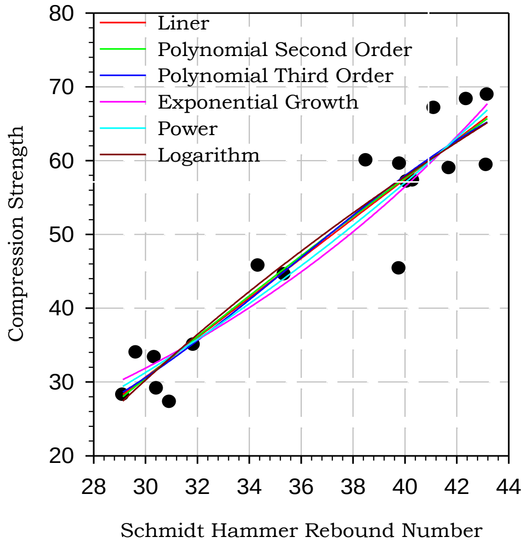

Fig. 3: Relation between cube (F'c) and (Rh)

Table 2: Relation between cube (F'c) and (Rh)

Relationship Types	Cube Compression Derivation(F'c)	Correlation Factor (R^2)
Linear	F'c = -49.82+2.683Rh	0.8958
Polynomial Second Order	F'c =-66.71+3.638Rh-0.013Rh^2	0.8960
Polynomial Third Order	F'c =196.3-18.4Rh+0.5916Rh^2-0.00554Rh^3	0.8966
Exponential Growth	F'c =5.741e$^{0.0575Rh}$	0.8859
Power	F'c =0.02598Rh$^{2.1}$	0.8926
Logarithm	F'c =-295+95.8Ln*Rh	0.8950

Relationship between cube compression and UPV:

The compression strength and UPV relationship are shown in figure 4. using different equations to fit the data. Based on the correlation factor (R^2) shown in table (3) obtained from the best curve fit the data. Polynomial Third Order fit the data quite well. However what should be used for the UPV is exponential growth equation that has R^2equal to 0.2394.

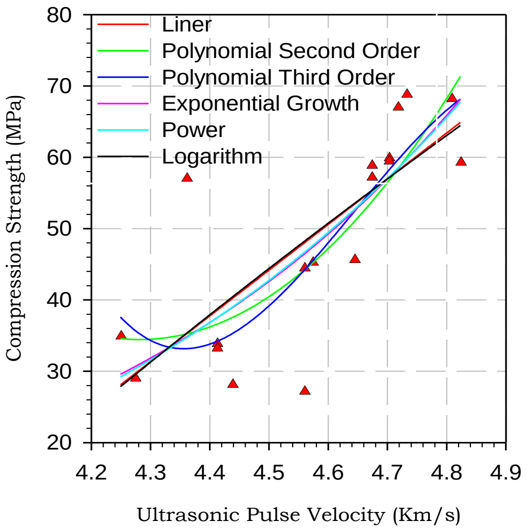

Fig. 4: Relationship between cube (F'c) and UPV

Table 3: Relationship between cube (F'c) and UPV

Relationship Types	Cube Compression Derivation (F'c)	Correlation Factor (R^2)
Linear	F'c = -244.4+64.13U	0.594
Polynomial Second Order	F'c =2338-1076U+125.7U^2	0.651
Polynomial Third Order	F'c =39630-25760U+5566U^2-399.4U^3	0.667
Exponential Growth	F'c =0.06136$e^{1.45U}$	0.626
Power	F'c =0.00197$U^{6.637}$	0.623
Logarithm	F'c =-390.3+289Ln*U	0.588

Conclusions:

A relationships between Schmidt hammer rebound number and cubes compressive strength of the Jufrah concretes were establish. The outcome of the research are a curves for Schmidt hammer rebound number and cubes compressive strength of concretes made of local materials from the Jufrah area. Also curves for Ultrasonic pulse velocity and cubes compressive strength for the same concretes. These curves could be used for any local concrete made from aggregates from the Jufrah.

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