EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE WITH PARTIAL REPLACEMENT OF FINE AGGREGATE WITH BRICK WASTE

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Abstract

This paper aims to achieve the green concrete making process by using recycled materials to lessen the negative impact on the environment. In this paper, the wasted bricks from brick manufacturing factories are reused as fine aggregate in the concrete making process. The brick dust is mixed into 5%, 15%, and 25% by weight of fine aggregate. Then the results from concrete specimens with brick powder are compared with the results of conventional concrete. The compressive and splitting tensile strengths of concrete samples are verified at designated curing days of 7 days, 14 days, and 28 days. After all of the strength tests, the standard deviation is calculated to analyze the errors in the results of concrete specimens by comparing them to conventional concrete. In this research, the concrete specimen with 5% of brick powder is the optimum value at compressive strength with 31.6 N/mm^2 and the concrete specimen with 25% of brick powder is the optimum value at splitting tensile strength with 1.39 N/mm^2. The optimum result at compressive strength is succeeded with concrete specimen with the lowest composition of brick powder and vice versa, concrete specimens with the highest composition of brick powder achieves the optimum result in splitting tensile strength in this research.

Keywords: Brick Powder, Compressive Strength, Splitting Tensile Strength, Standard De viation

Introduction

During the decade, the demand to construct the infrastructures and buildings is rising significantly with the continuous growth of the population. Rani & Jenifer (2016) stated that the manufacturing of concrete had been increased up to 11 billion metric tons annually and the composition of aggregates is the highest with the percentage of 70–75% including both fine and coarse aggregates and water comprises about 15% and the composition of cementation binder is around 10%.

The shortage of natural resources can trigger the growth of construction processes by consuming natural resources. Especially, sand mining for fine aggregate has a larger impact on nature as sanding mining is dependent and extracts from riverbeds and flood plains. Sand mining for fine aggregate can affect the ecosystem of aquatic lives in rivers, degradation to the river system, lessen river flows and depletion to the groundwater system, and so on. In the place of conventional materials, using wasted materials such as rubber, glasses, and bricks are becoming an interest to prevent the environmental impact and to recycle the waste materials. Therefore, during the recent years, many experimental processes and researches are undergone to develop concrete making technology by using recycled waste materials, which is termed “green concrete”.

The wasted brick is used as a replacement of fine aggregate since it can be bought cheaply in local markets. The wasted brick is usually used as hardcore or backfilling process and after doing the researches, the usage of wasted brick can be modified as fine or coarse aggregate in the concrete making process. According to the previous researches, using brick powder as fine aggregate increases the strength of concrete. Therefore, the purpose of producing green concrete can be accomplished by using brick powder as fine aggregate in concrete and this product will be able to use in constructing infrastructure in the future.

The aim and objective are to substitute the broken brick as fine aggregate in the place of natural sand to preserve the ecosystem and natural resources.

This research is processed to tackle down the environmental impact and develop a sustainable goal. In this research, the compressive strength and tensile strength tests of concrete specimens with different percentage composition of brick powder are carried out.

Siva, Thamilselvi, Devi, & Ashvini (2017) have done experimental investigation of crushed spent fire brick as a replacement in fine aggregate with a percentage of 10%, 15%, 20%, and 25%. The experimental process is focused on the tensile strength of crushed spent fire bricks. The concrete specimens are cured for 14 days and 28 days and three trial mixes are tested for each type. As a result outcome, the tensile split strength with 20% of the spent fire brick in concrete shows the optimum result with 2.89 N/mm^2 and the control result is 2.9 N/mm^2. Keerthinarayana & Srinivasan (2010) evaluated the various strength of concrete with spent fire clay brick as fine aggregate. The percentage composition of the brick powder is 0% to 30% with an increment of 5%.

The values of compressive strength, tensile strength, and flexural strength of concrete specimens with spent fire clay brick as fine aggregate are tested after curing days of 7 days, 14 days, and 28 days separately. The optimum content of spent fire clay brick in concrete specimens are 25% in compressive and tensile strengths and 20% in flexural strength.

In this research, the waste brick powder is mixed with natural fine aggregate by the composition percentage of 0%, 5%, 15%, and 25% in each type of concrete specimen. For four different parameters of concrete specimens, three trial concrete samples are tested to evaluate the average result. The compressive and splitting tensile strengths of concrete specimens with 0%, 5%, 15%, and 25% composition of brick powder as fine aggregate are tested after curing days of 7 days, 14 days, and 28 days. In this paper, the results from the tests of the concrete specimens are recorded and then they are compared to the results of the conventional concrete. The standard deviation is also calculated to evaluate how much the result is different from its mean value.

Methodology and Procedures

Concrete Mix Design

The concrete mix design of the concrete specimens is referred to as ACI 211.1-91 (ACI, 1991), which is applied to calculate the weight of required materials. The designated concrete strength used in this paper is Grade 30 or 4,350 psi and its design slump is 125 mm. The water-cement ratio has the greater influence on the strength of hardened concrete and it is inversely proportional to the strength of concrete (Perrie, 2009). The chosen water-cement ratio is 0.47 and the curing duration is set as 7 days, 14 days, and 28 days according to the standard of ASTM C192/C192M (ASTM International, 2002). The composition of materials in concrete processing is tabulated after the concrete mix design process as shown in Table 1.

Table 1 Concrete mix proportion (Kg/m^3) for concrete samples with various composition percentage of brick powder

Item	Cement (OPC)	Water	Fine Aggregates	Coarse Aggregates
Concrete samples -0% Brick powder (BP)	350	165	770	1,200
Concrete samples -5% Brick powder (BP)	350	165	38.5 (Brick powder) + 731.5 (Sand)	1,200
Concrete samples -15% Brick powder (BP)	350	165	115.5 (Brick powder) + 654.5 (Sand)	1,200
Concrete samples -15% Brick powder (BP)	350	165	192.5 (Brick powder) + 577.5 (Sand)	1,200
Concrete Mix Ratio	1	0.47	2.2	3.43

Physical Properties of Cement

The physical properties of cement used for concrete mixing are analyzed at the laboratory and the outcome results are acceptable when checking with BS EN-1:2000 (BSI, 2000). As the test of physical properties of cement, consistency percentage, penetration depth, initial setting time, soundness, 2 days and 28 days compressive strength of cement mortar prisms are tested. The outcome result of the physical properties of cement and standard of BS EN-1:2000 (BSI, 2000) are charted and compared as shown in Table 2.

Table 2 Physical properties test of cement provided by the laboratory

Physical properties of cement	Laboratory test result	Standard of BS EN-2:1000
Consistency (%)	29	Penetration point between 4 mm and 8 mm from the base of mold
Penetration (mm)	7	
Initial setting time (min)	105 min	≥ 60 min
Soundness	< 1	≤ 10 min
2 days compressive strength of cement mortar prisms	26.57 N/mm^2	≥ 10 N/mm^2
28 days compressive strength of cement mortar prisms	49.24 N/mm^2	Between 42.5 N/mm^2 and 62.5 N/mm^2

Customization of Particle Sizes of Brick Powder

As the wasted brick is substituted as the fine aggregate in the concrete, the broken brick can be bought cheaply. The broken brick is manually grounded into a fine powder. The grounded powder is dried naturally under sunlight.

Before the physical properties of brick powder is tested, the particle size of brick powder is selected by percent passing of sieve. The particle size of brick powder which passes sieve No.4 is used 5% by weight of brick powder and the particle size of brick powder which passes sieve No.200 is removed. After confirming the percent passing of brick powder, the sieved brick powder with various particle sizes is mixed according to the table shown in Table 3 and the properties of mixed brick powder are tested at the laboratory.

Table 3 Proposed percentage passing of brick powder with available sieve sizes

Sieve	Percent Mixing
4.75-mm (No.4)	5%
2-mm (No.10)	45%
850-μm (No.20)	
425-μm (No.40)	50%
250-μm (No.60)	
106-μm (No.140)	
75-μm (No.200)	Remove

Physical Properties of Aggregates and Brick Powder

The physical properties of both fine and coarse aggregates influence on the strength of hardened concrete. Therefore, the properties such as water absorption, specific gravity, fineness modulus, bulk density and organic impurities of the aggregates are tested and the results are tabulated shown in Tables 4–8. As an additional admixture, the physical properties of brick powder in the replacement of fine aggregate are also tested at the laboratory. According the results, water absorption rate of brick powder has higher percentage of water absorption compared to the natural fine aggregate. Moreover, the percentage of fine particle sizes, less than 0.075 mm is 28% of total grain sizes of brick powder. The grain size analysis is tested per ASTM D421-422.

Table 4 Physical properties of aggregates for concrete mixture

Item	Fine aggregate (FA)	Coarse aggregate (CA)	Brick powder (BP)	Standard Code
Water absorption (%)	0.58	0.25	7.55	ASTM C128 (FA)/ ASTM C127 (CA)
Specific gravity	2.60	2.62	2.57	ASTM C128 (FA)/ ASTM C127 (CA)/ ASTM D854 (BP)
Bulk density (kg/m^3)	1,559	1,515	1,251	ASTM C29
Organic Impurities	Color No.2	–	Color No.2	ASTM C40

Table 5 Sieve analysis and fineness modulus of fine aggregate

Sieve Size (mm)	Wt. of Individual Retained (g)	Wt. of Retained (%)	Cumulative Retained (%)	Cumulative Passing (%)	ASTM C33	
					Minimum	Maximum
9.50	0.00	0.00	0.00	100.00	100.00	100.00
4.75	3.90	0.78	0.78	99.22	95.00	100.00
2.36	3.40	0.68	1.46	98.54	80.00	100.00
1.18	6.00	1.20	2.66	97.34	50.00	85.00
0.60	24.30	4.86	7.52	92.48	25.00	60.00
0.30	219.60	43.92	51.44	48.56	5.00	30.00
0.15	206.70	41.34	92.78	7.22	0.00	10.00
0.075	30.20	6.04	98.82	1.18		
Pan	5.90	1.18	100.00	0.00		
Total	500.00	100.00				
Fineness Modulus	1.57					

Table 6 Sieve Analysis and fineness modulus of coarse aggregate

Sieve Size (mm)	Wt. of Individual Retained (g)	Wt. of Retained (%)	Cumulative Retained (%)	Cumulative Passing (%)	ASTM C33	
					Minimum	Maximum
37.50				100.00	100.00	100.00
25.00	161.00	3.22	3.22	96.78	95.00	100.00
19.00	209.50	4.19	7.41	92.59	-	-
12.50	574.30	11.49	18.90	81.10	25.00	60.00
9.50	534.50	10.69	29.59	70.41	-	-
4.75	1,774.40	35.49	65.07	34.93	0.00	10.00
2.36	1,232.70	24.65	89.73	10.27	0.00	5.00
Pan	513.60	10.27	100.00	0.00	-	-
Total	5,000.00	100.00				
Fineness Modulus			5.87			

Table 7 Sieve Analysis and fineness modulus of brick powder

Sieve opening (μm)	Sieve Size (mm)	Retained Soil Mass (g)	Retained (%)	Cumulative (%)	Cumulative P (%)	Corrected P (%)
	1.180	11.26	20.20	20.20	79.80	79.80
	0.600	10.40	18.66	38.87	61.13	61.13
	0.425	3.87	6.94	45.81	54.19	54.19
	0.300	4.95	8.88	54.69	45.31	45.31
	0.150	8.00	14.35	69.05	30.95	30.95
	0.075	1.00	1.79	70.84	29.16	29.16

Table 8 Grain size analysis of brick powder based on ASTM D421-422

Grained Size Analysis	Analysis Result
Gravel, (76.20 ~ 4.75 mm)	0.00%
Sand, (4.75 ~ 0.075 mm)	72.00%
Silt, (0.075 ~ 0.005 mm)	12.00%
Clay, (< 0.005 mm)	16.00%
Fine	28.00 mm
D60	0.5600 mm
D30	0.1350 mm

Preparation of Concrete Mixing

In this research, four types of concrete specimens with the various components of brick powder are defined as conventional concrete (0% brick powder) and concrete specimens with 5%, 15%, and 25% composition of brick powder, respectively, as shown in Table 9. For each concrete specimen, three samples are cast to calculate the average result of the strength. The compressive strength and splitting tensile strength of the concrete specimens are tested. For compressive strength test, cubes with standard dimensions of 150 mm x 150 mm x 150 mm mentioned in the code of BS 1881: Part 108: 1983 are used. Referring to ASTM C192 (ASTM International, 2002) and ASTM C496/C496M (ASTM International, 2004), cylinders with standard dimensions of 300 mm height and 150 mm diameter are used for splitting tensile strength test. Trial mixes for concrete specimens are processed at the laboratory and tabulated in Table 10.

Table 9 Four types of composition percentage of brick powder in concrete mixing

Composition	Cement (%)	Coarse Aggregate (%)	Fine Aggregate (%)	
			Brick Powder (%)	Sand (%)
1	100	100	0	100
2	100	100	5	95
3	100	100	15	85
4	100	100	25	75

Table 10 Trial mixes for concrete specimens with 0%, 5%, and 25% composition of brick powder

Date:	14-Dec-18	ST	BATCH
Mix-1		Design	vol
G-30		1 M^3	0.034
CEMENT–OPC (SCG 100%)		350	11.90
RS		1,200	40.80
Sand + Brick Powder		770	26.18
Water	Kg	165	5.61
yield		1,017	

Compression Test

The compression and splitting tensile strength tests are performed after their curing days of 7 days, 14 days, and 28 days respectively. The concrete cube samples are located centered to the lower plate of the machine. The loading is continuously applied without shock until the cracks occur and stops when the maximum strength of the concrete cube samples is reached. Then the compressive strength of the concrete samples is displayed on the screen, and it is noted.

Figure 1 Compression Test

Splitting Tensile Strength

Splitting tensile strength is tested by applying the compressive force along the longitudinal length of the cylindrical concrete samples. This compressive force loads tensile stress along the length of cylindrical concrete samples and tensile stress is induced to the samples rather than the compressive stress. This method is mostly used in measuring the shear resistance of the structural lightweight concrete by applying tensile stress to the cylindrical concrete sample.

Before the test is started, the additional steel plate is placed on the compression machine to extend the length which is shorter than the cylindrical concrete samples. Then the cylindrical concrete samples are placed on the steel plate and aligned to the centre of the upper compression plate. The load is applied without shock continuously within the range of 100 to 200 psi per minute. The load is applied until the failure of the cylindrical mould occurs. After the failure, the maximum applied load to the concrete samples and failure pattern is recorded. Then the splitting tensile strength for the concrete sample is calculated by the following equation described by American Society of Testing Materials (2004).

Figure 2 Splitting Tensile Strength Test

After the loaded force is collected the following equation is used to drive out the tensile strength of the concrete specimens.

$$\text{Tensile strength} = 2P/\pi LD \tag{1}$$

When,

P = Maximum applied load described by the testing machine

L = Length of cylinder

D = Diameter of cylinder

Results

Compression Test Results of Concrete Specimens

According the description of the Figure 3, 7 days compressive strength of concrete samples with 15% composition of brick powder shows the highest value out of other concrete samples with 0%, 5%, 15%, 25% and its highest average value is 16.18 N/mm^2. The strength of conventional concrete is 14.34 N/mm^2 and those of concrete samples with 5% and 25% composition of brick powder are 15.06 N/mm^2 and 13.85 N/mm^2 respectively.

After curing 14 days, the compressive strength of the concrete specimens is tested as the previous 7 days strength test. The compressive strength of concrete samples with natural sand rises significantly and the average value of 14 days and 7 days test results of concrete samples with 0% brick powder are 34.81 N/mm^2 and 14.34 N/mm^2 respectively. Even though the strength of concrete samples with different composition of brick powder is higher than 7 days results, the strength gaining rate is relatively slower compared to conventional concrete test results. The average compressive strength results of 5%, 15%, and 25% compositions of brick powder in concrete specimens after 14 curing days are 27.89 N/mm^2, 19.66 N/mm^2, and 17.71 N/mm^2 respectively.

In 28 days compressive strength test, the compressive strength of conventional concrete is 40.07 N/mm^2 which is the highest of all results. The compressive strength of concrete with 5% composition of brick powder is the highest out of other concrete specimens with brick powder and its result is 31.26 N/mm^2. The compressive strengths of concrete specimens with 15% and 25% are 23.37 N/mm^2 and 20.22 N/mm^2.

As more percentage of brick powder is added into concrete specimens, water absorption rate of concrete specimens with brick powder is higher than that of conventional concrete. Thus, although the compressive strengths of 15% and 25% content of brick powder in concrete samples are higher than the previous 14 days test results, the strength gaining rate is becoming slower and fails to reach 28 days target strength of 30 N/mm^2. According to the compressive strength results of 28 days curing concrete samples, concrete sample with 5%

composition of brick powder is the optimum rate that should be mixed in concrete mix design.

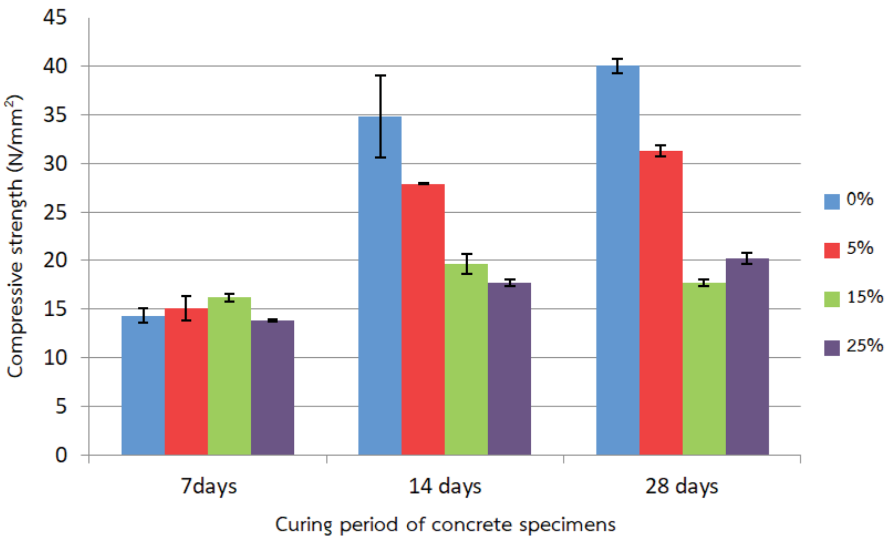


Figure 3 Compressive Strength of Concrete Specimens of 7 days, 14 days, and 28 days Curing Period with Error Bars

Splitting Tensile Strength Test Results of Concrete Specimens

Similar to the compression test of concrete samples, the splitting tensile test of cylindrical concrete specimens is carried out after 7 curing-days. The average value of concrete specimens with 5% composition of brick powder is 0.70 N/mm^2. The lowest value is resulted in the conventional concrete and its value is 0.44 N/mm^2. The average splitting tensile strength results of the concrete samples with 15% and 25% composition of brick powder are 0.47 N/mm^2 and 0.65 N/mm^2 respectively.

Compared to the 7 days splitting tensile strength results, 14 days splitting tensile result of conventional concrete is increased sharply up to nearly double of 7 days splitting tensile strength results where 14 days splitting tensile strength of conventional concrete is 0.81 N/mm^2.The splitting tensile strengths of concrete samples with 15% and 25% composition of brick powder are 0.72 N/mm^2 and 0.83 N/mm^2. Concrete samples with 5% content of brick powder is still the highest value among other concrete samples with brick powder, similarly, the same result is found in the previous 7 days strength test where its value is 0.86 N/mm^2. Unlike the previous splitting test results shown in Figure 4, the concrete samples with 25% composition of brick powder becomes the highest in splitting tensile strength in 28 days strength test. Its splitting tensile strength is 1.39 N/mm^2 while the concrete specimens mixed with 5% and 15% of brick powder are 0.94 N/mm^2 and 1.15 N/mm^2 respectively. The splitting tensile strength of conventional concrete is the lowest in 28 days strength test and its tensile strength is 0.73 N/mm^2.

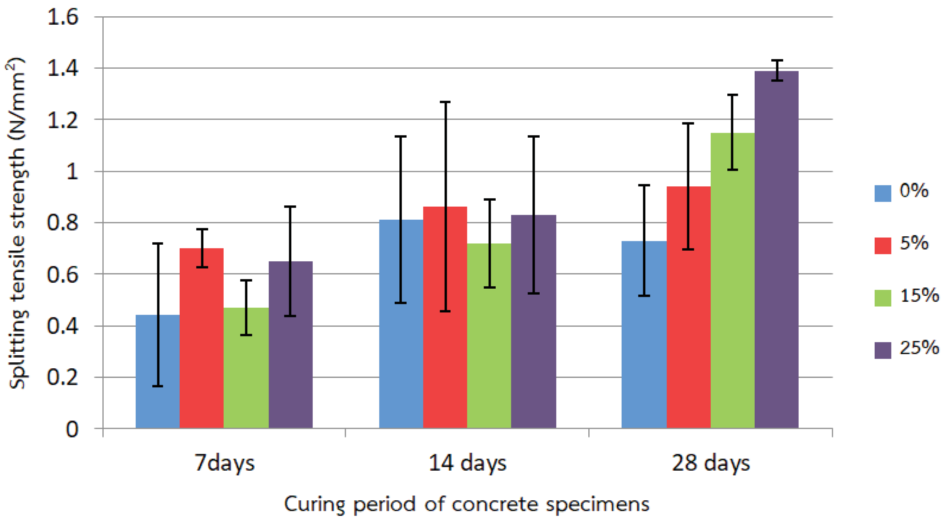


Figure 4 Splitting Tensile Strength of Concrete Specimens of 7 days, 14 days, and 28 days Curing Period with Error Bars

Discussion

In 7 days compressive strength test of concrete specimens, the conventional concrete is slower in compressive strength than other concrete specimens with composition of brick powder as fine aggregate. At 14 days compressive strength test, although the conventional concrete increases in compressive strength up to two times of strength at 7 days strength test, the concrete specimens with composition of brick powder are becoming slower and the concrete specimen with 5% of brick powder only shows significant strength increasing with the value of 27.89 N/mm^2.

At 28 days compressive strength test, the concrete specimens with 15% and 25% composition of brick powder fail to achieve the target strength of 30 N/mm^2 with the results of 23.77 N/mm^2 and 20.22 N/mm^2 respectively. The compressive strength of concrete specimen with 5% composition of brick powder is 31.26 N/mm^2 and it reaches to the target compressive strength of 30 N/mm^2. According to the analysis, the strength gaining rate of concrete specimens with brick powder is becoming slower as the curing duration of concrete specimens are longer. The water absorption rate of brick powder is relatively higher than water absorption rate of fine aggregate. Moreover, the 28% of brick powder which is under 0.075 mm, in the concrete samples influences water absorption rate of concrete specimens and tends to reduce the compressive strength of concrete specimens. Therefore, in this research, the concrete specimens with 5% of brick powder, which is the least composition of brick powder is the optimum result compared to other concrete specimens with 15% and 25% composition of brick powder.

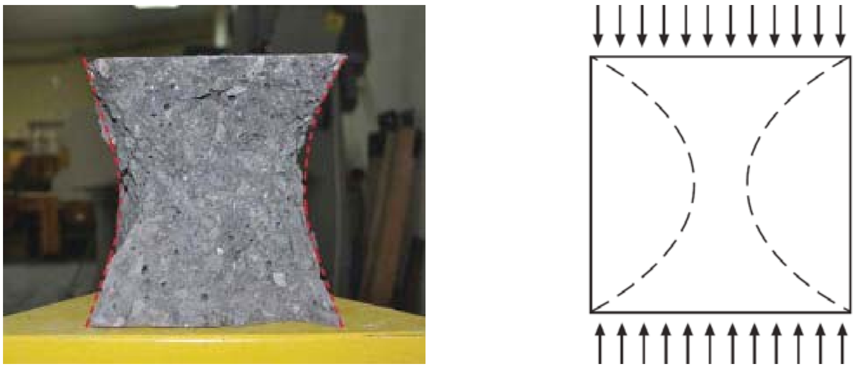
In splitting tensile strength test, concrete specimens with composition of brick powder show higher in strength increasing rate than conventional concrete. In 7 days and 14 days splitting tensile strength tests, concrete specimens with 5% composition of brick powder show the optimum value of 0.7 N/mm^2 and 0.86 N/mm^2 while the splitting tensile strength of conventional concrete is the lowest. At 28 days splitting tensile strength test, the concrete specimen with 25% composition of brick powder is the highest with the value of 1.39 N/mm^2. In compressive strength test, the concrete specimen with 5% composition of brick powder which is the lowest percentage composition of brick powder in this research shows the optimum value of 31.6 N/mm^2. However, in splitting tensile strength, the concrete specimen with 25% composition which is the highest composition of brick powder in research shows the strength result of 1.39 N/mm^2 that is higher than other concrete specimens.

The trends of increasing of splitting tensile strength and compressive strength of concrete specimens are different. The major effect influencing on the difference of the splitting tensile strength and compressive strength is moisture content. Chen, Huang, & Zhou (2012) mentioned that the moisture content has the significant effect on compressive strength but inversely, it has lesser effect on the splitting tensile strength of concrete samples.

When the maximum splitting stress on the concrete sample, reaches to the maximum within the narrow strip, which is along the central vertical plane of the concrete sample, the major pores of the coarse aggregate are broken down along the surface of the failure. Therefore, the moisture content has the lesser change on the splitting tensile strength compared to the compressive strength.

Moreover, according to Tsiskreli & Dzhavakhidze (1970), on increasing the maximum grain size to 120–180 mm, the tensile strength is decreased to 30–50%, compared with the concrete samples with maximum aggregate size 20 mm. In this research, the maximum size of coarse aggregates is 25 mm and thus, the splitting tensile strength of concrete samples increases properly. The nature of hardened concrete is the brittle material which is combined with different physical and mechanical properties of various materials. The concrete has strong resistance to compressive stress but almost fails to resist tensile stress. Therefore, during the compressing test, the frictional effect occurs between the specimen surface and the machine flat plane and that deliver the tensile stress as plastic deformation at the sides of the concrete specimens.

When the compressive load is applied to the surface of concrete specimen, the fractures propagate cross-section of the specimen and form perpendicular to the applied load (Perrie, 2009). This type of failure is also named as “Satisfactory Failure” as shown in Figure 5. According to BS 1881-116:1983, quality of casted concrete specimens, misplacement of the concrete cubes in the testing machine can deliver unsatisfactory failure as shown in Figure 6. During the compression and tensile splitting test of the concrete samples, irregular strength changes are detected and the unsatisfactory failure is found in some concrete specimens revealing the crack pattern in Figure 6 is similar to the crack pattern shown in Figure 6.



(a) (b)

Figure 5 (a) Satisfactory failure of compressive test
(Kovaþeviü & Džidiü, 2018)
(b) Multi axial state of stress due to compressive stress (Perrie, 2009)

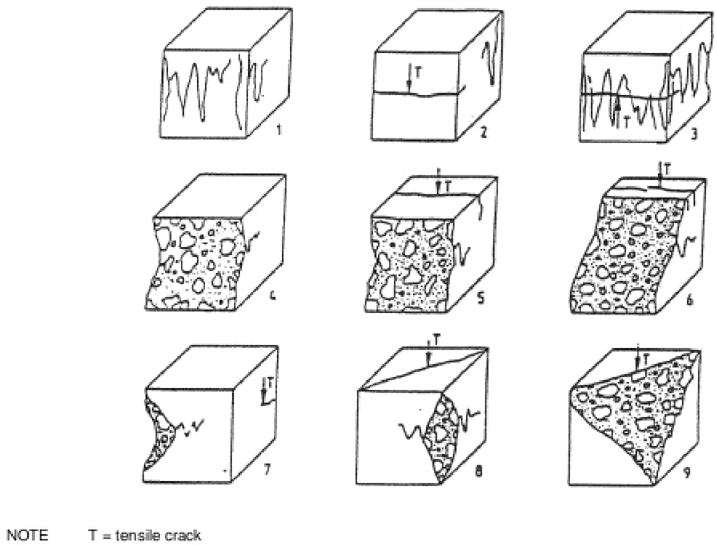


Figure 6 Unsatisfactory Failure

According to the results, the 28 days splitting tensile strength of conventional concrete is lower than 14 days splitting tensile strength. The probability is dependent on the error of specimen position while testing, which is able to deliver irregular result. Moreover, the irregular strength change in tensile strength can occur due to non-uniform drying of the concrete specimens.

Under the condition such as only the exterior surface of the concrete specimens is dried, can deliver tensile crack to the concrete specimen. Those tensile cracks can reduce the splitting tensile strength of concrete specimens (Chen, Huang, & Zhou, 2012). Therefore, reduction in the 28 days splitting tensile strength of concrete specimens is likely to occur due to the fact mentioned above.

After the results of concrete samples are analyzed, the standard deviation for each type of concrete samples is performed. The standard deviation is performed for the average value of three samples of concrete specimens with brick powder with different ratios of 0%, 5%, 15%, and 25% respectively. The standard deviation is calculated to evaluate the error bars graph. Through the error bars graph with the standard deviation, the result deviation from its respective mean value or average value can be checked. According to the data analysis, the higher rate of standard deviation is found out in 14 days compressive strength result of concrete specimens with 0% brick powder and in 7 days compressive strength result of concrete specimens with 5% brick powder with the deviation value over 1.

Conclusion and Suggestion

The main aim of this research is to reduce the environmental impact due to the extraction of sand for construction purpose from river bed and sand mining. The use of broken brick which is available in local with low price will be the option to be innovated as fine aggregate in concrete mixing.

According to the analysis, 5% composition of brick powder in concrete specimen is the optimum result in compressive strength in research. Its result achieves 28 days target strength of compressive strength of 30 N/mm^2. In splitting tensile strength test, the concrete specimen with 25% composition of brick powder is slightly higher than the splitting tensile strength of conventional concrete. Compared to other studies, Keerthinarayana & Srinivasan (2010) described that 25% composition of spent fire clay brick powder is the highest for both compressive and splitting tensile strengths.

Based on the results of this research, the research of partial replacement of fine aggregate with brick waste can be considered as green concrete and there are the advantages such as reducing usage of non-renewable resources such as sand, natural coarse aggregates (coarse aggregates) and recycling the waste materials in the place of conventional materials. Therefore, this research is really beneficial to reduce the environmental impact and to develop the sustainable environment.

As the recommendation on this study, water-cement ratio of the concrete mix design can be altered for different outcomes. The particle size of brick powder which is lesser 0.075 mm should be removed to support the strength of concrete specimens. As an advanced study, the help of chemical admixtures in concrete making process will also deliver more new researches and better results to develop the sustainable goal from engineering sector.

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