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Flexural Strength of Precast Concrete Panel with Onyx Waste by Surface Grinding Finishing Process with 4mm Thickness

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***Abstract*—** *This paper aims to reveal the research results on Onyx waste finishing process of precast concrete panel by using grinding process. The study was conducted at the Laboratory of Structure and Construction Materials of Brawijaya University, Malang, Indonesia; therefore, the parameters of the material and workers used were parameters that existed around the test site. The specimen made was a precast panel with dimension of 40 cm × 80 cm × 6 cm which was given a minimum horizontal reinforcement that is 3Ø10. The coarse aggregates used were split stone and onyx waste. The ratio of cement, sand, and coral, respectively, 1: 1.4: 1.7 aimed to make concrete onyx with fc' above 25 MPa. The panel will be flexed by loading in-plane with a three-point loaded process. From the research conducted, it can be a fast way and process in grinding concrete panels, the coefficient of work of grinding is the flexural strength of panel after grinding.*

***Keywords*—** *Concrete; Grinding; Onyx; Panel; Precast.*

I. INTRODUCTION

Concrete is a highly popular construction material used because it is easily formed, its strength and display are easily engineered, and constituent materials can be replaced provided that the replacement material still meets the applicable requirements. The researches on concrete continue to be developed to meet the needs of modern humans who not only require the strength of concrete. In this research, we want to improvise the display and the application of concrete in the form of precast panels.

Currently, the precast concrete business is experiencing an increase. Many requests from consumers to meet the needs of precast concrete. It is because precast concrete can save costs in terms of time, formwork, and labor.

Precast concrete panel is one of the many forms that can be produced by concrete plants. Generally, the panel is used as a barrier between rooms or as a protective part of the building from the outside. One of the keys to make inexpensive concrete products is by minimizing variations in form. This panel is very suitable to be the target of making precast concrete because in general the partition wall does not need many variations of other forms as well as on beams and columns.

Because the building blocks of concrete are easily modified, we can manipulate the concrete; therefore, it is in line as expected. To make it a partition, we can highlight the architectural properties of the concrete panel we are going to make. There are many ways to make concrete panel beautiful, such as painting the surface of concrete, mixing color pigments on fresh concrete, until grinding the concrete surface to peel a few mm from the concrete blanket until the coarse aggregate of concrete appears.

Onyx rock is one of the types of metamorphic rock, where the formation of onyx is due to the metamorphosis of limestone. Onyx stone is different from marble stone. The difference that can be seen visually is that onyx stone can be penetrated by light, whereas marble cannot. Onyx has a very random pattern that makes it suitable as a decoration material. In Indonesia, onyx stone is often found as stone that adorns houses, as stone used for floors, walls, and even furniture such as tables, benches, and so forth. The use of onyx leaves so many small fragments that can no longer be used as decoration materials. This initiates the idea to utilize onyx stone waste in which its size meets the standard as coarse aggregate instead of coarse aggregate in concrete mixtures. The expectation, when the concrete surface is grinded, will reveal unique patterns of onyx stone.

The grinding process is one of the finishing processes by peeling a thin layer from the mortar to cutting part of the coarse aggregate. The process of grinding concrete in the construction field is also known as honing or polishing depending on the level of fineness after finishing. The end result may look dull (honing) or very smooth and shiny (polishing). It depends on the cutting disc used and the type of coarse aggregate used. The finishing process by grinding is the most expensive method but it provides unique, beautiful and satisfying results.

The recommended mortar mixture for concrete to be grinded is a mortar mixture which its compressive strength is close to that of the coarse aggregate compressive strength. Thus, the grinding process will experience the same level of abrasion between aggregate and mortar. It will make the grinding result smooth without leaving a hole due to the release of aggregate particles. Grinding process can be done in wet or dry conditions. Wet grinding will leave material such as paste. The advantage is that dust does not fly but makes the engine performance become heavy. Dry grinding will make dust particles flying but the performance of the tool is not as heavy as wet grinding.

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II. EXPERIMENTAL PROGRAM

This study uses two types of aggregate coarse, split stone and onyx waste:

A. Material

The materials used as a concrete panel compiler is cement (Semen Gresik), sand (Lumajang sand), reinforcement 3Ø10, water (Municipal Waterworks), split stone and onyx waste. The split stone used is obtained from material stores around the testing laboratory. This stone has the same specifications as those used in development projects in the research area (Malang). The use of this material is used as a control of Onyx panel specimens.

Onyx waste used is obtained from Tulungagung, Indonesia. Here, there are many waste found from onyx stone business. In addition, there are many wastes left by craftsmen, so that if this waste is managed properly, it will provide a selling point for waste which is no longer used.

(a) (b)

Fig. 1. (a) split stone (b) onyx waste

The analysis of split stone and onyx waste gradation as coarse aggregates can be seen in TABLE 1 and Fig. 1.

TABLE 1. Coarse Aggregate Gradation

Sieve size	Split Stone		Onyx Waste		Cumulative % Passing	
	Mass Retained (g)	% Retained	Mass Retained (g)	% Retained	Split Stone	Onyx Waste
76	0	0	0	0	100	100
38	0	0	0	0	100	100
19	500	5	500	5	95	95
9.5	5400	54	5700	57	41	38
4.75	4100	41	3800	38	0	0
2.375	0	0	0	0	0	0
0	0	0	0	0	0	0
jumlah	10000	100	10000	100		

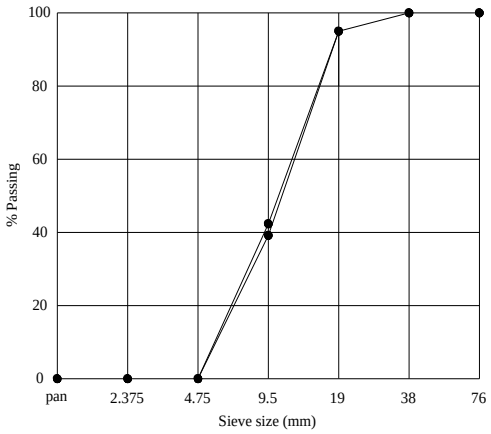

Fig. 2. Coarse aggregate sieve gradation

B. Speciment and Testing

This paper discusses a precast panel which is planned to be applied as a pair of ½ bricks. It can be seen in Fig. 3. The objective is to choose the ½ brick pair method, namely to reduce the dead load of buildings because. So far, the application of concrete panels is by using a steel frame coated with concrete panels on both sides.

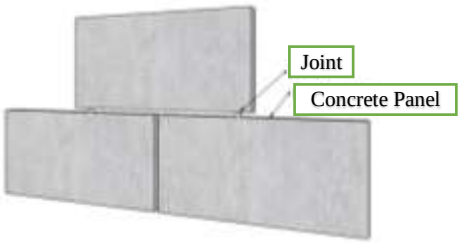

Fig. 3. Application Plan

To meet the expected plan, the specimens prepared are full-scale specimens measuring 6 cm × 40 cm × 80 cm (Fig. 4). Concrete panel using 3Ø6 reinforcement is mounted horizontally. Variable specimens prepared are panel made of non-grinding split stone and 4 mm thickness grinding, and panel made of non-grinding onyx waste and 4 mm thickness grinding.

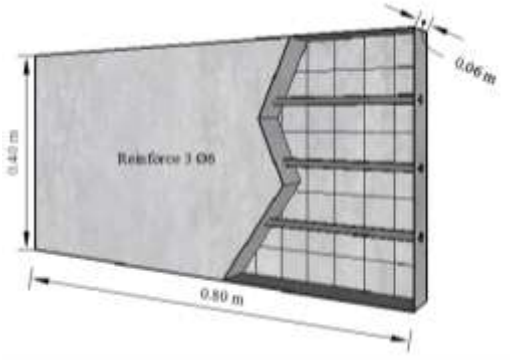

Fig. 4. Concrete panel test specimens

Tests which are conducted are by doing in-plane loading with the three point loaded method. It is done as an approach to the application plan which can be seen in Fig. 5. The load received by the beam will be distributed to the panel. The lower the location of the panel is, the greater the burden that will be received. It is because of its own weight from the panel above it. In the pedestal moment, sloof decreases, therefore, it will become a pedestal of 2 points and a loading of one centre point (three points loaded).

III. RESULT AND DISCUSSION

A. Material Testing

Tests conducted in this study include testing the property of coarse aggregate, compressive strength of concrete cylinders, and hammer tests on concrete panels. The property of coarse aggregate (TABLE 2) is needed to predict the concrete compressive strength of the plan. In this study, the composition of the mixture is made the same (TABLE 3), thus, the thing that happens is the compressive strength of onyx concrete will be lower than split stone concrete (TABLE

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4 & TABLE 5). The purpose of making concrete mix proportions is that the aggregate percentage that appears after grinding is expected to be the same between split stone concrete panels and onyx waste.

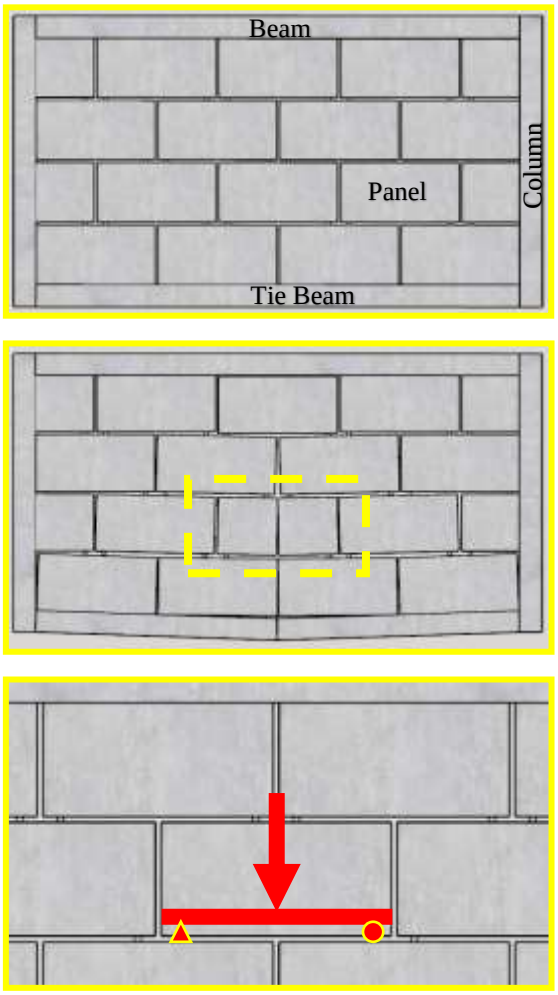

Fig. 5. Implementation Approach

TABLE 2. Onyx rock waste and coarse aggregate testing data

Experiment	Onyx	Split Stone
Bulk Specific Gravity	2.609	4.192
Saturated Surface Specific Gravity	2.632	4.319
Specific Gravity	2.669	4.192
Absorption (%)	0.864	0.030

TABLE 3. Proportion of concrete mixture

Ingredients	Semen (kg)	Air (kg/lt)	Fines Agregate (kg)	Coarse Agregate (kg)
Tiap m3 (Teoritis)	512.5	205	700,7	891,8
Tiap campuran uji 0,1 m3	51,25	20,5	70,07	89,18
Tiap m3 (Aktual)	512.5	212,2	696,1	889,1
Tiap campuran uji 0,1 m3	51,25	21,22	69,61	88,91

Flexural strength testing of panel is conducted on specimens which are around 1 year old. Concrete will increase in strength with a time of 1.35 times at the age of 1 year compared to the age of 28 days. To find out the compressive strength of concrete when the panel is in the flexural strength testing, a hammer test is performed. The hammer test results can be seen in (TABLE 6).

TABLE 4. The results of compressive strength testing of concrete cylinders with stone split coarse aggregate stone

No	Speciment	Load (kN)	Weight (kg)	Area (cm^2)	Compressive strength (Mpa)	Average Compressive strength (Mpa)
1	SN-1	537	12.56		30.38	
2	SN-2	548	12.43		31.00	
3	SN-3	694	12.9		39.26	
4	SN-4	467	12.94		26.42	
5	SN-5	534	12.65		30.21	
6	SN-6	577	12.8		32.64	
7	SN-7	637	12.69		36.03	
8	SN-8	528	12.78	176.79	29.87	31.75
9	SN-9	550	12.94		31.11	
10	SN-10	601	12.84		34.00	
11	SN-11	518	12.56		29.30	
12	SN-12	544	12.75		30.77	
13	SN-13	613	12.7		34.67	
14	SN-14	550	12.62		31.11	
15	SN-15	522	12.92		29.53	

TABLE 5. The results of compressive strength testing of concrete cylinders with onyx waste coarse aggregate

No	Speciment	Load (kN)	Weight (kg)	Area (cm^2)	Compressive strength (Mpa)	Average Compressive strength (Mpa)
1	SO-1	467	12.68		26.42	
2	SO-2	408	12.61		23.08	
3	SO-3	503	12.83		28.45	
4	SO-4	423	12.7		23.93	
5	SO-5	496	12.75		28.06	
6	SO-6	449	12.81		25.40	
7	SO-7	484	12.85		27.38	
8	SO-8	413	12.92	176.79	23.36	26.11
9	SO-9	461	12.78		26.08	
10	SO-10	486	12.61		27.49	
11	SO-11	435	12.82		24.61	
12	SO-12	466	12.63		26.36	
13	SO-13	539	12.79		30.49	
14	SO-14	424	12.78		23.98	
15	SO-15	471	12.81		26.64	

TABLE 6. The results of hammer test on concrete panels

No	Concrete Panel	Hammer Test	Compressive strength (kg/cm^2)	Conversion to fc' (Mpa)	Average fc' (MPa)
1	N - 0 - 1	40.50	444	36.86	40.17
2	N - 0 - 2	41.70	467	38.77	
3	N - 0 - 3	42.60	485	40.22	
4	N - 4 - 1	39.40	423	35.13	
5	N - 4 - 2	48.80	610	50.64	
6	N - 4 - 3	42.10	475	39.41	
7	O - 0 - 1	42.70	487	40.38	40.68
8	O - 0 - 2	46.00	552	45.85	
9	O - 0 - 3	39.20	419	34.81	
10	O - 2 - 1	41.60	465	38.61	
11	O - 2 - 2	40.90	452	37.49	
12	O - 2 - 3	46.80	569	47.20	
13	O - 4 - 1	44.80	528	43.84	
14	O - 4 - 2	44.00	512	42.51	
15	O - 4 - 3	39.60	427	35.44	

On the compressive strength results of concrete cylinders at the age of 28 days, it shows the results of 31.75 MPa for concrete with split stone; while for concrete with onyx waste of 26.11 MPa. At the age of 1 year, concrete has a

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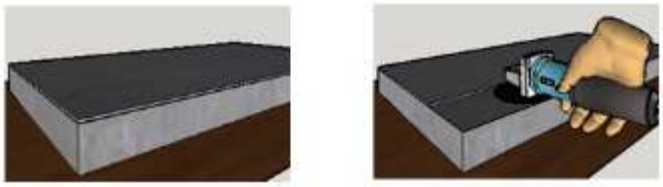
compressive strength increase of 1.26 times for concrete with a split stone to 40.17 MPa; whereas for concrete with onyx waste has increased strength by 1.55 times to 40.68 MPa.

B. Panel Grinding

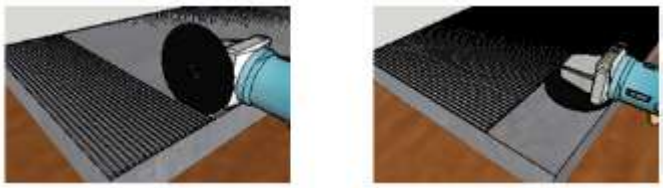
There are two ways of grinding process done in this test. First, it is direct grinding. Firstly, the part that we will be grinding is marked. Mark the four sides as thick as 4 mm, then peel a few times over and over until the thickness of the grinding reaches 4 mm (Fig. 6).



(a) (b)

Fig. 6. (a) mark the layer to be grinded of 4mm thickness (b) grinding bit by bit until the mark has been made

The second method is by chopping first and then grinding. First, mark the two sides which have 4 mm thickness. Cut up the concrete panel for 4 mm depth using a static eye cut with a spacing of about 5 mm. Then, grinding is done by using a special cutting disc for grinding. This process needs a relatively faster time and the same end result. It is because the concrete that has been chopped will be more easily crushed (Fig. 7)



(a) (b)

Fig. 7. (a) mark for 4mm thickness, then chop for 4 mm thickness with a distance of 5mm (b) the grinding of test specimens that have been chopped until smooth

Calculation of time, cost, and coefficient

To do the first grinding process, it takes 4 inch electric hand angle grinder and concrete turbo diamond grinding cup wheel. Work length of grinding with 4mm thickness for 1 concrete panel measuring 40 cm × 80 cm is about 85 minutes. If the coefficient of productivity is calculated from workers per test item $\frac{85}{8\times60} = 0.177$ OH or equal to 0.53 OH for each m^2 of 4 mm thick grinding.

To do the second grinding process, it takes 4 inch electric hand angle grinder, dry diamond wheel and concrete turbo diamond grinding cup wheel. The work length of 4mm thickness grinding for 1 concrete panel measuring 40 cm × 80 cm is about 35 minutes of chopping process and 23 minutes of grinding process. If the coefficient of productivity is calculated from workers per test item $\frac{58}{8\times60} = 0.121$ OH atau setara 0.38 OH untuk tiap m^2 grinding setebal 4 mm.

The minimum wage for labours in Indonesia is IDR 70,000 per day. Thus, if you the first process is done, the costs incurred for the grinding process is IDR 37,100.00/m^2. Whereas the second process is done, it costs IDR 26,600.00/m^2 for concrete grinding with a thickness of 4 mm.

Comparison of % shown from split stone concrete and onyx

The results of 4 mm thick grinding show that the percentage of coarse aggregate seems almost equal between split stone concrete and onyx waste concrete. Grinding results show aggregates seem around 30-40% (Fig. 8)

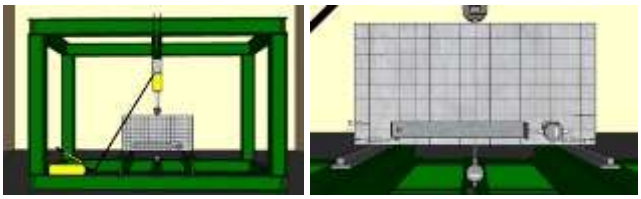
(a) (b)

Fig. 8. (a) split stone (b) onyx waste panel concrete

White onyx stone will look very contrast with the gray concrete. Using onyx as a substitute for coarse aggregate and finishing by using a grinding process will use gray monotonous concrete that will have architectural value with the white color of the onyx stone.

C. Panel Testing

The panel testing is done by giving an in-plane load and the panel is supported on 2 roll joints. The form of testing in the laboratory can be seen in Fig. 9. Tools used include LVDT and load cell. From these two tools, we can see the relation between the load and the deflection that occurs during the testing.



(a) (b)

Fig. 9. (a) tool setting and testing specimen (b) the close detail

The different behaviors of the grinding process done on onyx concrete panels and split stone concrete panels do not show significantly different results on the results of the panel's flexural strength test. It shows that the second grinding process can be carried out without reducing the flexural strength and provides the advantage to speed up the process and reduces the execution time.

O-4-I specimen is a panel with onyx waste concrete with the grinding process directly reaching the initial crack at 4098 kg loading, while O-4-II and O-4-III specimens by chopped grinding process reaching the initial crack first of 3958 kg load in average.

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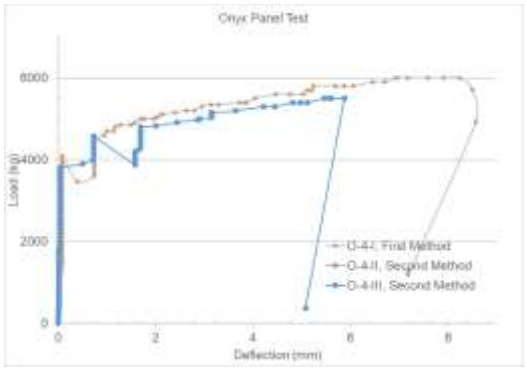
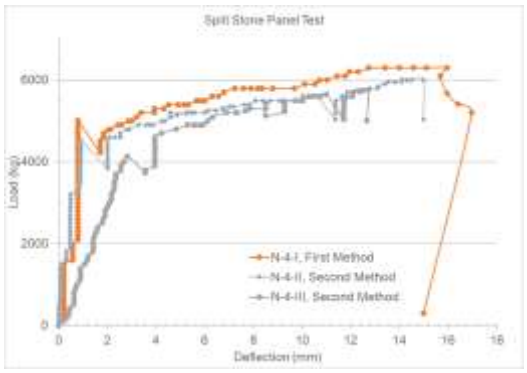


(a)



(b)

Fig. 10. (a) the test result of onyx panel (b) the test result of split stone panel

The N-4-I specimen is a panel with split stone concrete with the grinding process directly reaching the initial crack at 5014 kg, while the N-4-II and N-4-III specimens with the chopped grinding process first reaching the initial crack at 4557 kg load in average.

IV. Conclusion and Recommendation

Compressive strength of split aggregate concrete cylinder and onyx waste aggregate concrete at 28 days has different values. Compressive strength of split aggregate concrete is 31.75 MPa and onyx aggregate concrete is 26.11 Mpa.

The compressive strength of split aggregate concrete panel and onyx waste aggregate concrete at 365 days has increased. The compressive strength of split aggregate concrete panel is 40.17 MPa while onyx aggregate concrete is 40.68 MPa. Concrete with aggregate onyx waste has a slow increase in strength at 0-28 days. However, at 365 days, the average compressive strength of concrete with split aggregate is almost the same as the concrete with onyx waste aggregate which is around 40 MPa.

The percentage of aggregate seen in split concrete panel and onyx concrete panel after undergoing a 4 mm thick grinding process shows a result of 30-40%. It shows that the split and onyx aggregate spread behaviour is similar.

The process of grinding with chopping first is proven to be faster than the direct grinding process. The processing time for the chopping process is 58 minutes, while for direct grinding, it is 85 minutes. The difference in the grinding process does not show a significant difference in the panel's flexural strength.

The panel's flexural strength is taken from the initial crack value when the panel is loaded. On split concrete panel with 4mm thickness, the grinding process has initial cracks when receiving a load of 4557 kg while onyx concrete panel with 4mm thickness, the grinding process has cracking when receiving load of 4005 kg.

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