CRACKING STUDY OF ONYX WASTE PRECAST CONCRETE PANEL WHICH THE SURFACE IS FINISHED WITH 4MM THICKNESS GRINDING

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ABSTRACT

This research is a continuation of a series of research on Tulungagung onyx waste. The large volume of onyx waste in the area around the Tulungagung onyx processing plant is used as a substitute for gravel aggregate in the concrete mixture which is processed into exposed concrete which has high aesthetic value. In this study, a finishing treatment process (panel thickness thinning) was carried out which aims to produce coarse aggregates from the walls of the onyx concrete waste panels as exposed concrete which has high aesthetic value. The researcher wanted to know the cracking behavior of the onyx concrete waste panel walls before and after the finishing process. The test object used is the test object of previous researchers, namely the wall of the onyx waste concrete panel size 80 cm x 40 cm x 6 cm with practical steel reinforcement Ø6 - 100 mm attached, so that in this study the researcher only carried out the finishing treatment of panel thickness thinning, in-plane three-point loading test and took data on the cracks that occurred. The result of the finishing process by grinding of 2 mm shows that the percentage of aggregate is seen on average 1.8% of the total surface area, while for the finishing of 4 mm it shows that the percentage of aggregate is seen on average 35%. No initial cracks were found on the surface of the specimen after grinding 2 mm or 4 mm. The cracks experienced after loading were flexural cracks, where all the samples had only one crack in the direction almost perpendicular to the panel axis. The bending stress that occurs in the panels during the initial cracking of the non-grinding panels, 2 mm grinding panels, 4 mm grinding panels is 4.75 MPa, 4.62 MPa, 4.60 MPa respectively.

Keywords : concrete, cracks, grinding, onyx, panels, precast

1. INTRODUCTION

Waste is a residual production material whose tendency is to become garbage which often will have an impact on the surrounding community, so that thoughts are needed in terms of handling it, and thoughts on how to utilize the waste.

Previous research entitled *"Concrete with onyx waste aggregate as aesthetically valued structural concrete"* by Edhi Wahyuni Setyowati, et al. [1] from Civil Engineering Universitas Brawijaya, shows that the mechanical test results of the Tulungagung onyx waste concrete have a strength level that meets the requirements for use as structural concrete with a higher aesthetic level.

This research is a continuation of a series of research on Tulungagung onyx waste. The large volume of onyx waste which is located in the area around the Tulungagung onyx processing plant is used as a substitute for gravel aggregate in the concrete mixture.

The structure of the building studied is a precast concrete panel using onyx stone waste aggregate which can function as a wall in the actual building.

Generally, the walls are made of red brick and river stone covered with mortar on the outside. However, the use of walls using red bricks and river stones requires a relatively long installation time, costs and a lot of energy. Therefore, the innovation of precast concrete panels using onyx rock waste aggregate was carried out, the waste rock onyx used as a substitute for coarse aggregate in concrete was able to improve the porosity value of the concrete [2].

Onyx stone is a rock that has high aesthetic value with its beautiful white color and smoothness. Therefore, the resulting concrete does not need to be painted, but only grinded so that the concrete becomes smooth, and the color of the onyx stone is clearly visible. The waste that has accumulated so much has been used as an idea by researchers to use waste as a coarse aggregate of concrete which will be processed into exposed concrete which has high aesthetic value.

There are times when the wall as an important element of a house or building experiences problems, including the appearance of cracks in certain parts of the wall. Cracks in the walls may reduce the quality and strength of the building while reducing the aesthetics of the house or building.

Based on the description above, research on the cracking behavior of onyx waste concrete panels was carried out to support the feasibility study of onyx waste concrete wall panels as exposed concrete which has high aesthetic value.

2. LITERATURE REVIEW

2.1 Concrete

In the development of getting the selected material as a building material that is reliable and meets the demands of the times, concrete is an artificial stone that is still chosen as a building material.

The casting operation includes batching: cement, aggregate, water and admixture additives as planned and mixing them in a concrete mixer. The resulting fresh concrete is then transported to its final location where the fresh concrete is cast into the mold and compacted so that a solid mass is obtained and the hardening process of the concrete can begin [3].

2.2 Aggregates

Aggregates fill 60-80% of the volume of concrete. Therefore, the chemical, physical and mechanical characteristics of the aggregates used in the mixing greatly affect the properties of the resulting concrete (such as compressive strength, strength, durability, weight, production costs and others).

The properties of the aggregate depend on the properties of the host rock, its mineral and chemical composition, petrographic, density, physical stability and pore structure. The properties of the aggregates are independent of the nature of the host rock, the size and shape of the particles, the texture, and the surface absorption [4].

2.3 Onyx Stone

In this research, the type of waste aggregate is used, namely the coarse aggregate of onyx waste concrete. From the XRF test results, the results are shown in the following table, where it can be seen that the chemical elements contained in the onyx rock waste. The properties of the material can also be used to assess the compressive strength of the concrete to be made.

Table 1. Elements Contained in Onyx Stones

No	Element	(%)
1	Ca	98.39 +/- 0.29
2	Fe	0.13 +/- 0.009
3	Co	0.11 +/- 0.0008
4	Cu	0.045 +/- 0.001
5	Mo	0.32 +/- 0.03
6	Sm	0.32 +/- 0.03
7	Er	0.10 +/- 0.009
8	Yb	0.76 +/- 0.03

Source: XRF test results [3]

Table 2. Test Data for Onyx Rock Waste and Coarse Aggregate

Type of 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

Source: Aggregate testing research [3]

2.4 Concrete Waste Stone Onyx

The physical, mechanical and chemical properties of concrete with a mixture of onyx waste rock as an aggregate to replace crushed stone have been studied which shows a tendency for concrete properties to be quite good and can meet the required standards, a mixture with W/C ratio 0.4 in the concrete mixture with onyx stone waste aggregate produces the highest strength compared to other W/C ratio values [5], In terms of concrete porosity, the porosity value of onyx waste rock concrete shows a decrease in the porosity value [2], Meanwhile, the modulus of elasticity of concrete obtained an increase in the modulus of elasticity compared to normal concrete with crushed stone aggregate [6] which shows properties strongly support the possibility of using onyx rock waste as an aggregate in the concrete mixture.

The positive properties of concrete after it hardens so that it can be used as a building material and in the planning of a concrete mix according to the desired plan. The characteristics of the desired concrete include: high compressive strength, low price, the constituent materials are easy to obtain, easy to process, resistant to fire, durable, at least for a period of 30- 40 years, not experiencing damage, as well as in terms of financing and costs. relatively cheap maintenance. Concrete is also resistant to high temperatures and anti-corrosion, strength at the age of 28 days, will reach strengths above 80%.

2.5 Wall Panels

Wall panels or better known as wall panels are one of the non-structural components of a building. In general, walls or walls are made in the field using red bricks covered with mortar. In large volumes and the location of buildings in areas that require special treatment, such as in earthquake areas and multi-storey buildings, making walls with red bricks and working in the field will have an adverse impact on a building, such as old work, wasteful of labor, heavy kind of high and dangerous when an earthquake occurs [7].

In this study, the researcher wanted to examine the cracking behavior of onyx waste concrete panel walls which were given in-plane load. This is because the building wall in terms of building physics carries out several functions or a combination of the following functions [8]:

1. The load carrier function on it
2. The function of closing or dividing the room, both visual and acoustic
3. Facing the outdoors and the inside

2.6 Importance of Cracks and Their Relationship to Aesthetic Value

There are times when the wall as an important element of a house or building experiences problems, including the appearance of cracks in certain parts of the wall. Cracks in the walls may reduce the quality and strength of the building while reducing the aesthetics of the house or building.

Cracks in walls have various forms, some are vertical, deviated cracks, smooth cracks and others.

The initial crack in the surface could be a potential source of further component failure. Although these types of cracks are not too dangerous, they can reduce the aesthetic value of a component in a building.

Cracks in structures develop at the sites of the highest stress and weakest attachments [9]. Concrete can crack at the beginning of loading because this material is weak against pull. The adhesion tension between the reinforced steel and the surrounding concrete (bond strength) is the main parameter that affects the crack and crack width.

According to Amri [10], cracks can occur for a variety of reasons. In the early stages of damage to structural components begins with deflection. If the allowable deflection limit is exceeded, the stage of damage will continue in the flexible crack. If the flexural ability is exceeded, the damage will continue at a higher stage, namely in the form of shear cracks. According to McCormac [11], bending crack is a vertical crack that extends from the tensile side of the beam and points upward to its neutral axis.

Cracked in concrete is a contribution and the beginning of a more severe impression, namely the ongoing process of steel reinforcement corrosion, damage to the concrete surface and other long-term damage impacts. Therefore, knowledge of crack behavior and control of crack width is important in calculating the long-term feasibility of loading structural components [12].

2.6.1 Initial Micro-Crack on the Surface

The presence of cracks will cause the equipment from the surface grinding process to not function properly. In the surface grinding machining process, cracks that occur in the workpiece are caused by the depth of cut factor [13]. In addition, the type of abrasive, the cooling method used and the thermal conductivity of the grinding stone are also thought to affect the occurrence of cracks due to the release of mortar from the concrete.

If a surface of the workpiece resulting from the grinding process is further observed, the surface morphology shows that the different parameters of the surface grinding process cause different surface crack densities. Surface cracks are a potential source for component failure, so it is necessary to qualify the degree of cracks using objective standards.. Qualification by estimating the width, length or depth of cracks or even the number of cracks is not easy to do. Oleh karena itu, Lee dan Tai [14] define a surface crack density as the ratio between the total crack length in the observed cross-section to the area of the observed cross-sectional area, to evaluate the severity of the cracking. Thus, the surface crack density (SCD) can be formulated as follows:

$$SDC = \frac{\text{the length of the cracks observed}}{\text{observed cross} - \text{sectional area}} \quad (1)$$

2.7 Compressive-Force Path Concept

The *Compressive-Force Path* (CFP) concept is based on a precise understanding of concrete as a material and, as such, provides a rational alternative to address some of the shortcomings of current design thinking. On the basis of this concept, the load bearing capacity of the structural concrete components is related to the strength of the concrete in the track region where the compressive force is transmitted to the support. The compressive force path can be visualized as a 'flow' of compressive pressure with various parts perpendicular to the direction of the path, the compressive force represents the resultant stress on each part as shown in **Figure 1**. The crack development pattern will never enter the compression area. The crack will only be perpendicular to the compressive stress [15].

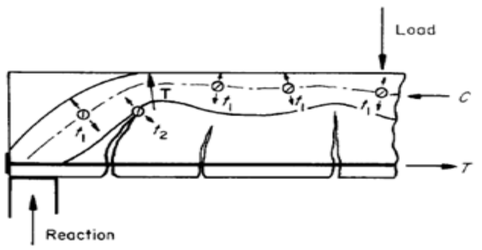

Figure 1. Schematic Representation of A Compressive-Force Path

2.8 Grinding or polishing of exposed concrete panel walls

The grinding of the onyx concrete panel walls aims to add to the aesthetic value of the concrete, so that the panel walls made are not only strong but also beautiful when viewed. Grinding is done when the concrete is> 28 days old, this is because the condition of the concrete is already hard at that time. Grinding of the concrete, done with a stone grinding tool.

The basis for choosing the exposed concrete method is to give an abstract artistic impression that is produced by the natural style of onyx stone as a constituent of concrete. In addition to changing people's views that concrete is just a structural material that looks monotonous which is far from an aesthetic impression, it can also use waste materials that no longer have a selling price into goods that are more valuable after being processed into exposed concrete.

3. RESEARCH METHODOLOGY

3.1 Research Approach

After finishing (thinning the thickness of the panels which causes the laitance to disappear) the strength will increase or decrease. In addition, due to collisions with finishing tools, is there a mechanism for panel damage such as initial cracks on the surface which could be a potential source for component failure. Researchers hypothesize that the finishing process is carried out to make coarse aggregates appear to eliminate other weaknesses apart from reducing the thickness of the panels themselves.

This concrete panel functions as a partition / non-structural arrangement which is shaped like a half brick masonry. This test needs to be done because the taller the panels are arranged, the load problem must be there if deformation occurs, the heavier the load is carried by the panel at the bottom, considering that the load transmitted is the cumulative load from the panel above. Therefore, the researchers modeled this test as a panel that receives an in-plane external force in the middle of the span which is likened to the transfer of gravity loads from the above panel.

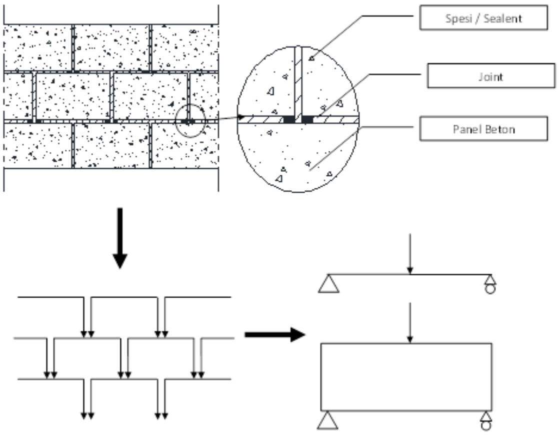

Figure 2. Structural Modeling Mindline

3.2 Speciment and Testing

In this study, the test object was in the form of onyx concrete panel walls with a size of 80 cm x 40 cm x 6 cm with practical steel reinforcement Ø6 - 100 mm attached.

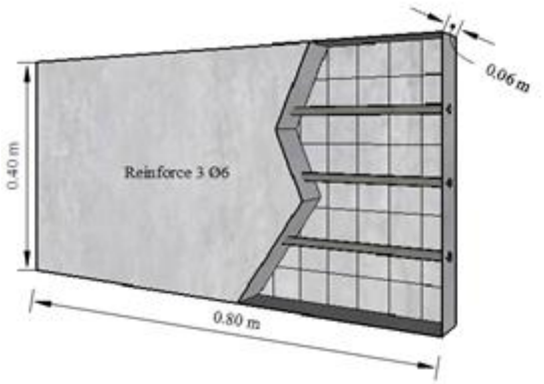

Figure 3. Concrete Panel Wall Specimens

The test object used is the test object of previous researchers, namely the wall of the onyx waste concrete panel size 80 cm x 40 cm x 6 cm with practical steel reinforcement Ø6 - 100 mm attached, so that in this study the researcher only carried out the finishing treatment of panel thickness thinning, in-plane three-point loading test and took data on the cracks that occurred.

The number and code of test objects in this study are summarized in **Table 3** :

Table 3. Test Object

No	Type	Code	Amount
1.	Onyx Aggregate Concrete Panel Wall Without Grinding	O-0-I	1
		O-0-II	1
		O-0-III	1
2.	Onyx Aggregate Concrete Panel Wall with Grinding 2 mm	O-2-I	1
		O-2-II	1
		O-2-III	1
3.	Onyx Aggregate Concrete Panel Wall with Grinding 4 mm	O-4-I	1
		O-4-II	1
		O-4-III	1

Testing on the panel is done with in-plane load and the panel is focused on 2 joints and rollers.

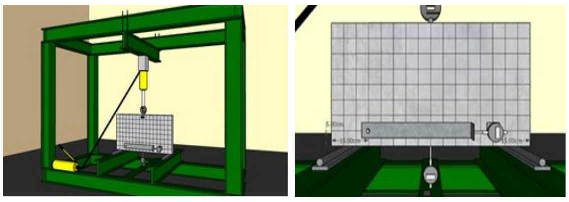

Figure 4. Testing Settings

From **Figure 4** we can see the test using the three point loading test model. The pedestal used is a roll joint that is installed with a distance between the supports of 70 cm leaving 5 cm to the edge of the panel on the grounds that the collapse is expected in the form of a flexible collapse in the middle of the span. The vertical LVDT mounted below in the middle of the span is used for reading the deflection when a load is applied. While the horizontal LVDT is installed 5 cm from the bottom edge of the panel used as a strain reader when the load is applied. Between the hydraulic jack and load distributor, a load cell is installed as a load reader that will be given to the panel.

3.3 Panel Grinding

The grinding of the onyx concrete panel walls aims to add to the aesthetic value of the concrete, so that the panel walls made are not only strong but also beautiful when viewed. Grinding is carried out when the concrete is ± 28 days old, this is because the condition of the concrete is already hard at that time. Grinding of the concrete, done with a stone grinding tool.

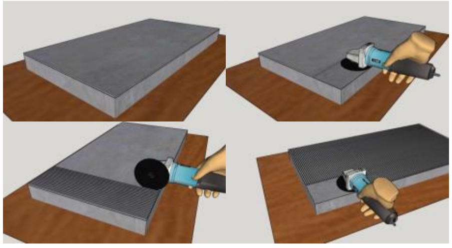

Figure 5. Grinding Process

3.4 Testing Phase

Some of the research activities carried out in laboratory tests are as follows:

a. Panel wall property measurement
   1. Take the test object from the place of care after> 28 days.
   2. Measuring dimensions and actual weight of each specimen.
   3. Hammer Test.

b. Measurement of physical changes to the panel walls after finishing
   1. Photographing test specimens of panel walls after finishing.
   2. Image processing is performed with the help of software, to calculate the percentage of aggregate visible after finishing.
   3. Observation of initial micro cracks on the surface using Dinolite.

c. In-plane loading test for concrete panel walls

   The following are the steps in testing the in-plane loading of the concrete panel walls:
   1. Put the test object on the loading frame according to the test settings in **Figure 4**.
   2. Install dial gauge, LVDT and Dinolite at the specified location later in the reading set.
   3. Carry out tests with load control in multiples of 100 kg until it reaches peak load, then proceed with displacement control.
   4. Take notes on the readings of each tool, and draw the crack patterns that occur.
   5. Repeat the above steps for each specimen.

4. RESULTS AND DISCUSSION

4.1 Hammer Test

At the time of performing the flexural test of the concrete panels, the age of the panel specimen has entered more than 28 days, therefore a non-destructive test is carried out using a hammer test. Hammer test used by the *Schmidt Concrete Test Hammer N Type (Proceq)*.

The results of the compressive strength of concrete cylinders aged 28 days (from previous research data) show the results of concrete with onyx waste an average of 26.11 MPa [16].

The results of the compressive strength test using the Hammer Test are used as the basis for the analysis of the calculation of the flexural strength of the panels. This is because the results of the concrete cylinder compressive strength test are considered irrelevant.

Table 4. Hammer Test Results

Concrete Panel	Hammer Test	Compressive strength (kg/cm^2)	Conversion to fc' (Mpa)	Average fc' (MPa)
O - 0 – I	42.70	487	40.38	40.68
O - 0 - II	46.00	552	45.85	
O - 0 - III	39.20	419	34.81	
O - 2 - I	41.60	465	38.61	
O - 2 – II	40.90	452	37.49	
O - 2 - III	46.80	569	47.20	
O - 4 - I	44.80	528	43.84	
O - 4 - II	44.00	512	42.51	
O - 4 - III	39.60	427	35.44	

From the hammer test results on panels that are approximately 1 year old, it shows that the compressive strength of the concrete has increased. The average compressive strength on the onyx concrete panels is 40.68 MPa. The ratio of the increase in compressive strength that occurs is 1.55 times in onyx concrete.

4.2 Grinding Onyx Panel

There are several ways to finish concrete panels such as painting, exposed concrete (concrete look), and exposing coarse aggregates. To expose coarse aggregate itself, there are several ways such as grinding (thinly peeling the layer of concrete to give a smooth impression), grinding (peeling the surface of the concrete mortar layer to scrape off the coarse aggregate), sanding (sprinkling brush coral on the half-hardened concrete surface). In this research, finishing is done using grinding techniques. The grinding technique was chosen because the onyx stone waste used was in the form of broken aggregates which had sharp edges so it was impossible if the method used was like the *ampyangan* method. The hope of the grinding process is that coarse aggregate embedded in hard concrete will be exposed smoothly when the hard concrete surface is scrapped with a certain thickness.

Figure 6. Onyx Concrete Panel With 4 Mm Thickness Grinding

Onyx waste concrete panel walls after finishing with grinding of 2 mm show that the percentage of aggregate is visible on average 1.8% of the total surface area, while grinding of 4 mm shows that the percentage of aggregate is seen on average 35% of the total surface area.

4.3 Initial Crack on the Surface

The grinding process in this study resulted in a collision of the test object with the finishing tool, whether there was a panel damage mechanism such as initial cracks on the surface which could be a potential source of component failure. One of the things we can observe is whether there is an initial crack on the surface. Based on observations using a USB digital microscope, no initial cracks were found on the surface of the specimen after grinding 2 mm or 4 mm.

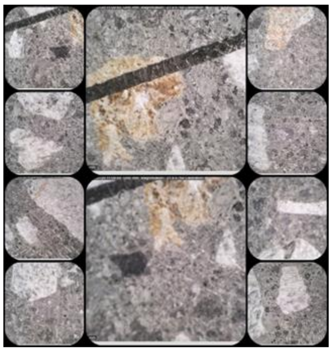

Figure 7. Observation Of Early Surface Cracks

4.4 Crack Pattern

The cracks experienced after loading the walls of the onyx waste concrete panel before and after finishing were flexural cracks, where all samples had only one crack in the direction almost perpendicular to the panel axis.

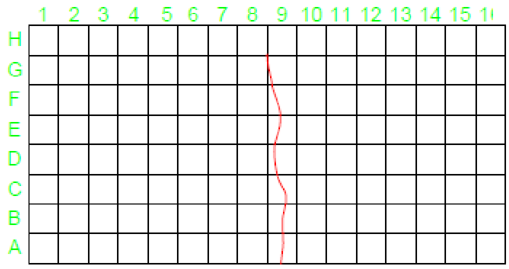

Figure 8. Typical Panel Crack Patterns

4.5 Comparison of Beginning to Crack of Onyx Concrete Panel Before Grinding and After Grinding

Based on the results of the observations that have been made, the data used as a comparison of the walls of the onyx waste concrete panel before being grinded and after grinding are obtained as shown in **Figure 8**.

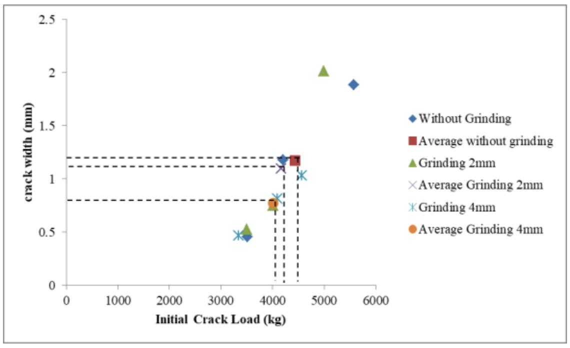

Figure 8. Graph Of Crack Width Difference When Load First Crack

Based on the observation of the measurement of the crack width between the walls of the onyx waste concrete panel before grinding with the onyx waste concrete panel wall after being grinded when the load first cracked, the average crack width of the onyx waste concrete panel walls before grinding was 1.173 mm, with the largest crack width which is 1.884 mm and the smallest crack width is 0.458 mm. Where the load starts to crack the average that occurs is 4430.67 kg, with the largest starting load of cracking at 5576 kg and the smallest starting load of 3516 kg.

After 2 mm of onyx waste concrete panel

walls grinded, the average crack width was 1.097 mm, with the largest crack width of 2.014 mm and the smallest crack width 0.528 mm. Where the average load starting to crack that occurs is 4165.33 kg, with the largest starting load of cracking which is 4988 kg and the smallest starting load of 3504 kg.

After 4 mm grinding of the onyx waste concrete panel walls, the average crack width was 0.771 mm, with the largest crack width of 1.033 mm and the smallest crack width 0.466 mm. Where the load starting to crack the average that occurs is 4004.67 kg, with the largest starting load of cracking at 4570 kg and the smallest starting load of 3346 kg.

Thus, the crack width of the onyx waste concrete panel wall before being grinded when the load was first cracked was greater than the crack width of the onyx waste concrete panel wall after grinding. Meanwhile, the initial load occurred onyx waste concrete panel wall crack before grinding was greater than the initial load, the onyx waste concrete panel wall crack occurred after grinding.

4.6 Analysis of Panel Bending Stress during Initial Crack

Although seeing cracks, what is being tested is a bending test so that the bending stress results. We will know the concrete stress, it turns out that the flexural stress in our model specimen is so. The reduced bending capacity needs to be compared with the dimensions of the panels themselves. Because we also need to know that the reduction in thickness due to grinding can weaken the panel, or still have the same strength to withstand the load. Researchers will compare the ratio of the moment of cracking and inertia of each treatment. Given that moment is an external force acting up to crack the panel and inertia itself is the tendency of all physical objects to resist changes to their state of motion.

In the onyx stone aggregate concrete panel, the strength decreased by 2.75% at grinding 2 mm and 3.16% at grinding 4 mm. Seeing the test results, the researchers concluded, the change in flexural capacity is only affected by changes in the thickness of the panels. Meanwhile, other factors such as initial cracks due to grinding, vibration and abrasion on the panel surface are considered not to have a significant effect.

Table 5. Flexural Testing Results

	Formula	O - 0	O - 2	O - 4	unit
length (l)		70.00	70.00	70.00	cm
thick (b)		6.00	5.80	5.60	cm
height (h)		40.00	40.00	40.00	cm
Pcr (avg)		4431	4165	4005	kg
Mcr	1/4 P.l	77537	72893	70082	kg.cm
Inertia (I)	$1/12\ b.h^3$	32000	30933	29867	cm^4
Ratio	M/I	2.42	2.36	2.35	
Decrease in strength		0.00	2.75	3.16	%

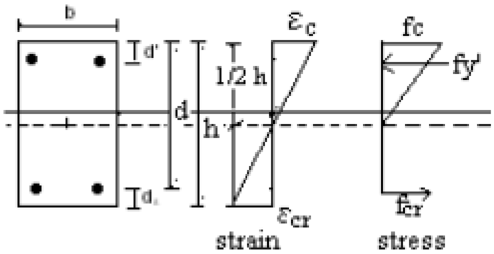

Figure 9. First Crack Condition [17]

Figure 9 illustrates the conditions at the time of the first crack. It is assumed that the neutral line is located at the center of gravity of the concrete section, and the outer tensile stress of the concrete has reached the maximum tensile stress of the concrete (f_{cr}), so we get the moment and curvature of the first crack. Researchers want to see the crack phenomenon that occurs in conventional beams to be close to the test results on the panel. According to Suprayitno [18], the tensile capacity of concrete with onyx coarse aggregate with concrete using gravel coarse aggregate does not experience a significant difference. therefore the calculation of the maximum tensile stress of concrete is approached using the equation :

$$f_r = 0{,}62\ .\ \lambda\ .\ \sqrt{f'_c} \qquad (2)$$

$$f_{r(rata-rata\ onyx)} = 0{,}62\ .\ 1\ .\ \sqrt{40{,}68} = 3{,}95\ MPa$$

Then the maximum tensile stress of concrete with onyx stone aggregate is obtained at 3.95 MPa. From the analytical approach data regarding the maximum tensile stress of concrete, an analytical calculation is made of the flexural stress that is able to withstand the panels until the panels experience the first crack. Thus we can find out the bending stress in our test object model can be seen in **Table 6**.

Table 6. Analysis of Bending Stress that Occurs in Panel During Initial Crack

	Formula	O - 0	O - 2	O - 4	unit
Compressive strength (f_c')	hammer test	40.68	40.68	40.68	MPa
Dimensions	L	70.00	70.00	70.00	cm
	h	40.00	40.00	40.00	cm
	b	6.00	5.80	5.60	cm
Kuat tarik (f_t)	$0.62 \lambda \sqrt{fc}$	3.95	3.95	3.95	MPa
I	1/12 b . h^3	32000	30933	29867	cm^4
$P_{(cr)\ avg}$	hasil lab	4431	4165	4005	kg
Bending Stress (σ)	M.y/I	48.46	47.13	46.93	kg/cm^2
Bending Stress (σ)	M.y/I	4.75	4.62	4.6	MPa

From the above analysis, at the time of initial cracking, we can say that the influence of the reinforcement is not yet dominant even though it does exist. Because the initial crack of any concrete and reinforcement will all work together, but the initial crack of this specimen model is because the area of reinforcement is not installed for the structure, we can already estimate the flexural stress roughly as shown in **Table 7** below:

Table 7. Bending Stress That Occurs In The Panel During The Initial Crack

Onyx Concrete	Bending Stress (σ)	unit
O - 0	4.75	MPa
O - 2	4.62	MPa
O - 4	4.60	MPa

With such magnitude of bending stress, there are many benefits. Subsequent research leads to benefits, what kind of tension the connection must be like, if you want to continue the *prototype* like what and others.

5. CONCLUSIONS AND IMPLICATIONS

5.1 Conclusion

The result of the finishing process by grinding of 2 mm shows that the percentage of aggregate is seen on average 1.8% of the total surface area, while for the finishing of 4 mm it shows that the percentage of aggregate is seen on average 35%. Based on observations using the help of a USB digital microscope, no initial cracks were found on the surface of the specimen after grinding 2 mm or 4 mm. The cracks experienced after loading were flexural cracks, where all samples had only one crack in the direction almost perpendicular to the panel axis. The bending stress that occurs in the panels during the initial cracking of the non-grinding panels, 2 mm grinding panels, 4 mm grinding panels is 4.75 MPa, 4.62 MPa, 4.60 MPa respectively.

5.2 Implication

At the time of the initial cracking we can say that the influence of the reinforcement is not yet dominant even though it does exist. Because any initial cracking of concrete and reinforcement will all work together, but the initial crack of this specimen model is due to the area of reinforcement being installed not for the structure, we can approximate the flexural stress. With such magnitude of bending stress, there are many benefits. The next research can be directed to the benefits, what kind of tension the connection must be, if the prototype is to be continued, and others.

During the compaction process of the concrete mixture, it is necessary to pay close attention, because there is always a risk of bleeding and segregation. The rising of water to the surface will cause a high ratio of water to cement to the concrete mixture on the surface, which in turn results in low compressive strength of the concrete on the surface. Laintance can result in porous concrete because the water rising to the surface forms a cavity, thus affecting the strength of the concrete.

In order to observe in more detail about the changes in stress and strain that occur due to cracks caused by in-plane loading, it is best to add a strain reader parameter in the next study. The author recommends attaching a steel strain gauge to each steel reinforcement and attaching a concrete strain gauge to the outer concrete tensile fiber whenever possible.

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