CHAPTER III
RESEARCH METHODOLOGY

3.1 Flowchart

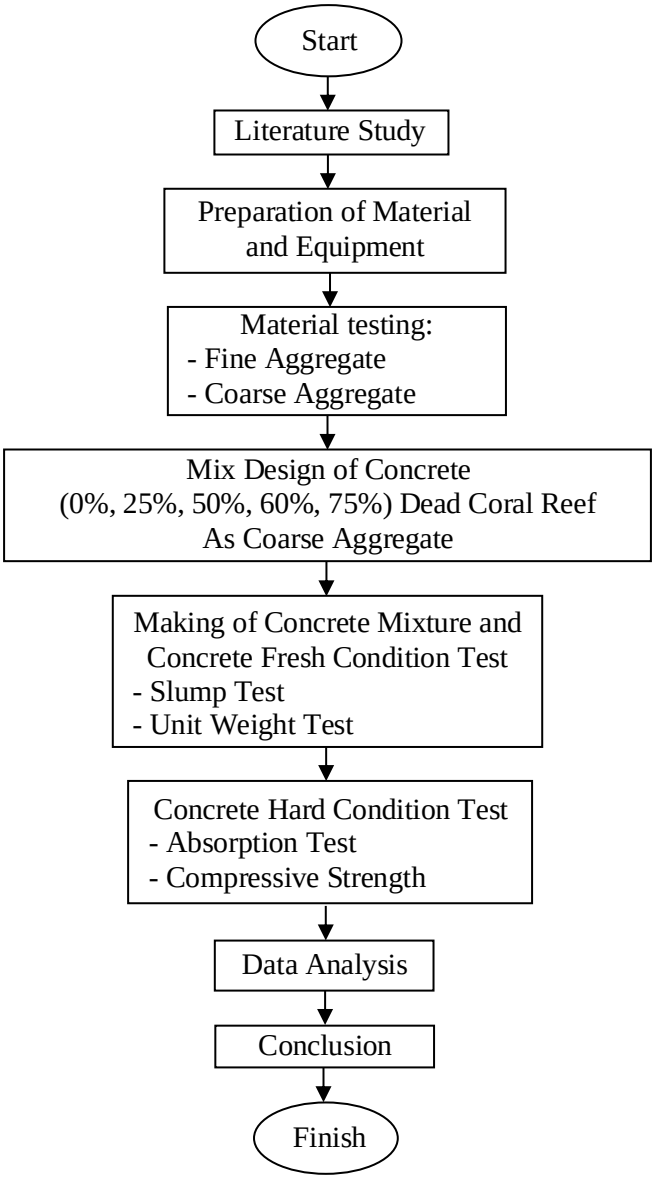

Figure 3.1 Flowchart of Research
(*Source: Author, 2024*)

3.2 Place of Research

Research on the manufacture of concrete using coral as coarse aggregate is carried out at the Laboratory of Civil Engineering, Universitas of 17 Agustus 1945, Surabaya, Indonesia.

3.3 Literature Study

Literature study is a method used to collect data or sources related to the research topic. References can be taken from research journals, books, articles and online sites. The literature study aims to strengthen the problem, as a theoretical basis in the studies conducted and as a basis for conducting concrete test.

3.4 Preparation of Material and Equipment and Material

3.4.1 Preparation of Material

In this study using the following materials;

1) Cement
   Using Type I cement, namely Gresik cement
2) Sand
   Using natural sand as fine aggregate
3) Water
   Using clean water in the Laboratory of Civil Engineering, Universitas 17 Agustus 1945 Surabaya.
4) Crushed gravel
   Crushed gravel is used as a coarse aggregate in concrete
5) Dead coral reefs
   Dead coral reefs taken from around the coast of Kampung Lobuk is used as coarse aggregate in concrete. The following is the process of taking dead coral reef material from Kampung Lobuk:
   - The dead coral reefs were taken from the shore of Kampung Lobuk.
   - The dead coral reefs taken were approximately ± 37.5 mm in size, then cleaned of trash.
   - The prepared dead coral reefs were then transported and brought to the Civil Engineering Laboratory of Universitas 17 Augustus Surabaya using a car.
   - After which it is screened using a 37.5 mm sieve to ensure that the size of the coral is no larger than 37.55 mm.
   - If the coral is stuck on the 37.5 mm sieve, it is broken down into several pieces.

3.4.2 Preparation of Equipment

In this study using some of the equipment as follows:

1) Scales for weighing materials and test objects.
2) One set of ASTM sieves and sieve shaker machine is used for sand grade inspection.
3) Measuring cup for measuring cement, sand and water.
4) Oven to make the test object dry.
5) Wire basket as a tool to determine the unit weight of coarse aggregate.
6) Los Angeles machine and steel balls for wear testing of coarse aggregates.
7) Concrete mixer or mixer for mixing the test material.
8) Concrete mold with a diameter of 10 cm and a height of 20 cm for printing infiltration specimens.
9) Concrete mold 15 cm long and 30 cm high to print compressive strength specimens.
10) Crushed compressive strength test machine for testing the compressive strength of concrete.
11) Trays and buckets as containers or places for materials in the manufacture of samples of concrete specimens.
12) Abraham tube and steel plate for slump test.
13) Tamping rod for cornering the concrete mixture, and other tools.

3.5 Material Testing

To find out the material data that will be used as a concrete mixture, it is necessary to do material testing. The following material tests will be carried out in this study:

3.5.1 Fine Aggregate Testing

To determine the characteristic properties of fine aggregate required in a concrete mixture, fine aggregate testing is required. Testing is carried out in accordance with the Buku Petunjuk Praktikum Beton UNTAG (2022) as follows:

1. Sand Sieve Analysis Test
   a) Purpose of test
      Tests were carried out to measure the size distribution/grade of sand
   b) Material used
      Sand in an oven dry condition
   c) Equipment used
      - The digital balance has a capacity of 30,000 grams

- One set of ASTM sieve #4, #8, #16, #30, #50, #100, pan.
- Vibrator (sieve shaker)
- Scrubbing brush
- Tray

d) Testing steps
- Weighing the oven sand as much as 1000 grams.
- Arrange sieves by placing the largest diameter at the top and then sorting according to diameter.
- Put sand in the sieve that has been arranged in the top sieve.
- Put a sieve that has been filled with sand on top of the vibratory machine, then adjust the locking screw.
- Turn on the vibrating machine for ± 10 minutes.
- Weigh the sand remaining in each sieve

2. Sand Moisture Test

a) Purpose of test

Testing is done to find out or determine the water content of natural sand.

b) Material used

Sand in its original condition

c) Equipment used
- Digital Balance with a capacity of 30,000 grams
- Oven
- Tray

d) Testing steps
- Weighing sand 500 grams
- Put the sand in the oven at (110 + 5) ºC for 24 hours.
- Remove the sand from the oven, then weigh it after it cools down.

3. Sand Volume Weight Test

a) Purpose of test
- Testing is done to determine the volume weight of sand both in loose and solid condition.

b) Material used

Oven-dried sand made by putting sand samples into an oven with a temperature of (110 ± 5) ºC for 24 hours.

c) Equipment used
- Balance
- Cylinder measure
- The tamping rod is a round, straight steel rod made of iron with a diameter of 16 mm and a length of 60 cm

- Tray

d) Testing steps without stabbed
   - Weigh the measuring cylinder that is dry, then measure the height and diameter of the dose.
   - Fill the cylinder with dry sand then level the surface.
   - Weighing a cylinder filled with sand

e) Testing steps with stabbed
   - Weigh a dry and clean cylinder and then measure its height and diameter.
   - Filling the cylinder in three stages, namely filling the sand into the cylinder up to 1/3 of the height of the cylinder and pounding it 25 times, then filling the cylinder again until the sand fills 2/3 of the height of the cylinder and pounding it 25 times, then refilling the cylinder dose, use sand until it is full and must exceed the height of the cylinder after that it is pounded 25 times.
   - Flatten the surface of the sand according to the height of the cylinder and then weigh it.

4. Sand Absorption Test

a) Purpose of Test

This test was carried out to determine the infiltration water content in SSD (Saturated Surface Dry) sand.

b) Material used

SSD condition sand as much as 500 grams

c) Equipment used
   - Digital Balance with a capacity of 30,000 grams
   - Oven
   - Tray
   - The truncated cone is made of metal with a minimum thickness of 0.8 mm with a height of (75 ± 3) mm, and with a diameter of (40 ± 3) mm at the top and (90 ± 3) mm at the bottom of the cone.
   - Tamping rod, a round, straight steel rod that has a flat surface, weight (340 ± 15) grams, and the diameter of the fist surface (25 ± 15) grams.

d) Step of Testing
   - Weighing sand in SSD conditions as much as 500 grams
     To make sand in the state of SSD (Saturated Surface Dry), the method is as follows:
     - First, fill sand into 1/3 of the cone and then pound it 25 times. The cone is filled with 3 layers that are each pounded 25 times.

- Lifting the cone if the sand inside is still conical and the outer sand slides, then the sand condition can be said to be SSD condition.
- If when the cone is lifted, the sand does not collapse or slide, the sand must be dried again. Otherwise, when the cone is lifted, all the sand collapses, then this condition has passed the SSD condition. Then we have to make it from scratch again.

- Putting the sand that has been weighed into the oven for 24 hours or until dry with the oven temperature (110 ± 5) ºC.
- Remove the sand from the oven and let it stand for a while, then weigh it after the sand has cooled

5. Sand Relative Density Test
   a) Purpose of Test
      Sand relative density test was carried out to determine the unit weight of sand in Saturated Surface Dry (SSD) conditions.
   b) Material used
      SSD condition sand
   c) Equipment used
      - Digital balance with a capacity of 30,000 grams
      - Volumetric flask 500 cc
      - The truncated cone is made of metal with a minimum thickness of 0.8 mm with a height of (75 ± 3) mm, and with a diameter of (40 ± 3) mm at the top and (90 ± 3) mm at the bottom of the cone.
      - Tamping rod that has a flat surface, weight (340 ± 15) grams, and the diameter of the pounder surface (25 ± 15) grams.
   d) Step of test
      - Prepare sand test specimens for SSD condition
      - Weigh a 500-cc volumetric flask and record the results.
      - Considering the SSD condition sand as much as 500 grams
      - Put the sand that has been weighed into the volumetric flask.
      - Weigh the volumetric flask that has been filled with sand as a control.
      - Add distilled water up to 90% of the contents of the volumetric flask. then rotate while shaking until no air bubbles are visible.
      - Add water until it reaches the line mark on the volumetric flask.
      - Weigh a measuring flask filled with water and sand, then record the results.
      - Clean the sand that is in the volumetric flask from bubble.
      - Fill the volumetric flask up to the line with water.

6. Sand Bulking Test
   a) Purpose of test
      The purpose of this test is to determine the volume percentage of air contained in the voids between the granules.
   b) Material used
      - Natural sand
      - Water
   c) Equipment used
      - Measuring cup 500 cc
      - Stirring rod
   d) Step of test
      - Put the sand into the rice, measure ± ¾ part, then measure the volume of the sand.
      - Pour the sand from the measuring cup into the sand tray until it is clean, nothing should be scattered.
      - Fill water into the measuring cup ± 1/2 part.
      - Put the sand back into the measuring cup little by little while stirring, then let it stand for ± 4 to 8 hours after that measure the volume of sand in the water.
7. Sand Cleanliness Test Against Material Finer than (No. 200) Sieve by Dry Method
   a) Purpose of test
      Testing is done to find out the amount of mud and sand
   b) Material used
      - Oven dry sand
      - Water
   c) Equipment used
      - Digital balance 30,000 grams
      - Sieve No. 200
      - Oven
      - Tray
   d) Step of test
      - Weigh 1000 grams of oven dry sand.
      - Wash the sand until it is clean, by placing the sand in a container filled with water and then squeezing it until it looks cloudy.
      - Sieve the washing water using a No. 200 sieve until it runs out. Material retained on the sieve is returned to the container.
      - Perform procedures number 2 and 3 repeatedly until looks clear.

- Transfer the washed sand to a tray and then bake it at (110 ± 5) ºC for 24 hours.
- Remove the sand from the oven then weigh it after it cools down.

3.5.2 Coarse Aggregate Testing

To determine the characteristic properties of the coarse aggregate needed in the concrete mix, it is necessary to test the coarse aggregate. Testing is carried out in accordance with the Buku Petunjuk Praktikum Beton UNTAG (2022) as follows:

1. Coarse Aggregate Sieve Analysis Test
   a) Purpose of test
      Tests were carried out to measure the size distribution/grading of coarse aggregate
   b) Material used
      Coarse aggregate in an oven dry condition
   c) Equipment used
      - Digital scales have a capacity of 30 kg
      - One set of ASTM sieve #1.5", #$^{3}/_{4}$", # 3/8", # 4.75, # 2.38 mm.
      - Tray
   d) Testing steps
      - Weighing the oven coarse aggregate with the provisions:

Table 3.1 Minimum aggregate weight requirements (ASTM C136-14)

Maximum sieve diameter	Minimum aggregate weight
3/8" (9.5 mm)	1 kg
1/2" (12.5 mm)	2 kg
3/4" (19 mm)	5 kg
1" (25 mm)	10 kg
1.5" (37.5 mm)	15 kg
2" (50 mm)	20 kg
2.5" (63 mm)	35 kg

(*Source: Buku Petunjuk Praktikum UNTAG, 2022*)

- Pouring coarse aggregate on a sieve with the largest sieve size placed on top.
- The sieve is swung one by one and provides a bottom container to accommodate the coarse aggregate that passes until no aggregate passes.

- Weigh the coarse aggregate retained in each sieve.

2. Coarse Aggregate Moisture Test
   a) Purpose of test
      Tests are carried out to determine or determine the water content or moisture content of coarse aggregate in its original condition.
   b) Material used
      Coarse aggregate in its original condition
   c) Equipment used
      - Balance with a capacity of 30,000 grams
      - The oven is equipped with temperature control to heat up to (110 + 50) ºC.
   d) Testing steps
      - Weigh the original coarse aggregate according to the minimum weight
      - Put the coarse aggregate into the oven at (110 + 5) ºC for 24 hours.
      - Removing the coarse aggregate from the oven, then weighing it after it has cooled down.
3. Coarse Aggregate Volume Weight Test
   a) Purpose of test
      Testing is done to determine the volume weight of coarse aggregate both in loose and solid state.
   b) Material used
      Coarse aggregate in the oven dry state which was prepared by placing the sand sample in the oven at (110 ± 5) ºC for 24 hours.
   c) Equipment used
      - Scales/Balance
      - A measuring cylinder has a volume of 10 liters.
      - The pounder tool is made of iron with a diameter of 16 mm and a length of 60 cm
      - Iron ruler
   d) Testing steps without stabbed
      - Weigh the measuring cylinder that is dry, then measure the height and diameter of the dose.
      - Fill the cylinder with dry coarse aggregate then level the surface.
      - Weigh the cylinder that already contains coarse aggregate
   e) Testing steps with stabbed
      - Weigh a dry and clean cylinder and then measure its height and diameter.

- Filling the cylinder in three stages, namely filling the coarse aggregate into the cylinder up to 1/3 of the height of the cylinder and piercing it 25 times, then filling the cylinder with coarse aggregate again until the height of the sand fills 2/3 of the height of the cylinder and is punctured 25 times, then refilling. The cylinder dose uses coarse aggregate until it is full and must exceed the height of the cylinder after that it is punctured 25 times.
- Leveling the surface of the coarse aggregate according to the height of the cylinder and then weighing it.

4. Coarse Aggregate Absorption Test
   a) Purpose of Test
      This test was carried out to determine the infiltration water content value in SSD (Saturated Surface Dry) coarse aggregate.
   b) Material used
      Coarse aggregate in SSD condition, this aggregate is made by soaking the coarse aggregate in water then removed after 24 hours and wiped one by one until the surface is dry.
   c) Equipment used
      - Scales with a capacity of 5 kg
      - The oven is equipped with temperature control to heat up to (110 + 50) ºC.
      - Tray
   d) Step of Testing
      - Weighing 3000 grams of coarse aggregate in SSD condition
      - Putting the weighed coarse aggregate into the oven for 24 hours or until dry with the oven temperature (110 ± 5) ºC.
      - Remove the coarse aggregate from the oven and let it stand for a while, then weigh it after the aggregate has cooled
5. Coarse Aggregate Relative Density Test
   a) Purpose of Test
      Coarse aggregate relative density test was carried out to determine the weight of coarse aggregate in Saturated Surface Dry (SSD) conditions.
   b) Material used
      Coarse aggregate in SSD condition
   c) Equipment used
      - Analytical scales with a capacity of 5 kg are equipped with a wire basket hanging device
      - Wiping cloth

- Basket
- Tray
- The water tank/bucket must be equipped with a pipe in order that the water level is always constant.

d) Step of test
- Prepare specimens for coarse aggregate in SSD condition
- Weighing the coarse aggregate that has been wiped as much as 3000 grams.
- Weigh the basket in the water and write the result.
- Put 3000 grams of SSD coarse aggregate into the wire basket, then weigh the wire basket containing the coarse aggregate by hanging the basket on the water hanger.

6. Coarse Aggregate Cleanliness Test Against Mud by Dry Method

a) Purpose of test

Testing was done to find out the amount of coarse aggregate mud

b) Material used
- Oven dry coarse aggregate
- Air

c) Equipment used
- Analytical balance 30000 grams
- Sieve No. 200
- Oven
- Tray

d) Step of test
- Weigh as much as 1000 grams of oven dry coarse aggregate.
- Wash the coarse aggregate until it is clean, by placing the coarse aggregate in a container filled with water and then squeezing it until it looks cloudy.
- Filter the washing water using a No. 200 filter until it runs out. Material retained on the sieve is returned to the tray.
- Do steps 2 and 3 repeatedly until the washing water looks clear.
- Transfer the washed coarse aggregate to the tray and then put it in the oven at (110 ± 5) ºC for 24 hours.
- Remove the coarse aggregate from the oven and then weigh it.

7. Coarse Aggregate abrasion test

a) Purpose of test

The objective of the coarse aggregate abrasion test was to determine the percentage wear of the gravel by a Los Angeles machine.

b) Material used

Coarse aggregate in oven condition and coarse aggregate grading.

Table 3.2 Grade of coarse aggregate

Size of Sieve				Weigh and Grade of Test Specimen (g)						
Pass		Retained		A	B	C	D	E	F	G
mm	inch	mm	inch							
75	3.0	63	2½	-	-	-	-	2500±50	-	-
63	2 1/2	50	2.0	-	-	-	-	2500±50	-	-
50	2.0	37.5	1 1/2	-	-	-	-	5000±50	5000±50	-
37.5	1 1/2	25	1	1250±25	-	-	-	-	5000±25	5000±25
25	1	19	3/4	1250±25	-	-	-	-	-	5000±25
19	3/4	12.5	1/2	1250±10	2500±10	-	-	-	-	-
12.5	1/2	9.5	3/8	1250±10	2500±10	-	-	-	-	-
9.5	3/8	6.3	1/4	-	-	2500±10	-	-	-	-
6.3	1/4	4.75	No.4	-	-	2500±10	2500±10	-	-	-
4.75	No.4	2.36	No8	-	-	-	2500±10	-	-	-
Total				5000±10	5000±10	5000±10	5000±10	10000±10	10000±10	10000±10
Total of balls				12	11	8	6	12	12	12
Weigh of balls				5000±25	4584±25	3330±20	2500±15	5000±25	5000±25	5000±25

(*Source: Buku Petunjuk Praktikum UNTAG, 2022*)

c) Equipment used

- Los Angeles Machine
- 12 steel balls
- Sieve No.12; #38.2; #25.4; #19.0;
- Balance capacity of 30 kg
- Tray

d) Step of test

- Prepare the test object according to the grade and weight, choose only one grade.
- Enter the test object and steel balls according to the table selected.
- Spin the Los Angeles machine
- After screening is complete, then remove the test object from the machine and then filter it using a No.12 sieve. The granules retained on the No.12 sieve were washed thoroughly after that they were put in the oven for 24 hours at a temperature of (110 ± 5) ºC.
- Remove the gravel from the oven and weigh it when it cools down.

3.6 Concrete Mix Desain

To find out the composition or proportion of the concrete constituents, it is necessary to plan or design a concrete mix called a mix design. In this study, the mix design was carried out using the SNI 03-2834-2000 method "Procedures for Making a Normal Concrete Mix Plan" which refers to the DOE (Department of Environment).

1. Define standard deviation (s)

   The standard deviation is obtained from experience in the field during concrete production, with the following equation:

   $$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \underline{x})^2}{n-1}} \quad \text{.....3.1}$$

   Where:

   s = standard deviation

   x_i = Compressive strength

   $\underline{x}$ = Average compressive strength

   $\underline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$

   n is the total value of the minimum test results of 30 pieces (one test result is the average value of 2 test objects)

   To calculate the standard deviation, data is used that must meet the following conditions:

   a) Represent materials, quality control procedures, and production that are similar to the proposed work.
   b) Represents f'c (required concrete compressive strength) whose value is within ±7 MPa of the specified f'c value.
   c) Consists of at least 30 consecutive test results or two groups of consecutive test results with a minimum number of 30 test objects. Taken in production for a period of not less than 45 days.
   d) If a concrete production does not have test results that meet the requirements, but there are only 15-29 consecutive test results, then the standard deviation value is the multiplication of the standard deviation calculated from the test results data with a multiplier factor.
   e) If the test result data is less than 15, then the targeted compressive strength is taken at f'c + 12 MPa.

3. Determine added value or margin (M)

   Value added or called margin is calculated using the following formula:

   $$M = 1.64 \times S \quad \text{.....3.2}$$

   Where: s = standard deviation

4. Calculating the planned average compressive strength can be calculated from the standard deviation and the added value/margin. The design compressive strength can be calculated using the following formula:

$$f'cr = f'c + M \quad \text{..... 3.3}$$

$$f'cr = f'c + 1.64\ Sr \quad \text{..... 3.4}$$

Where:

f'cr = Planned average compressive strength (MPa)

f'c = Required concrete compressive strength (MPa)

M = Value added/margin

Sr = plan standard deviation

1.64 = Statistical setting, value depends on the percentage of failure results test by a maximum of 5%

Table 3.3 The average strength is necessary if not available standard deviation

Requisite compressive strength (MPa)	Average compressive strength required (MPa)
f'c < 21 f'cr = f'c + 7	f'cr = f'c + 7
21 ≤ f'c ≤ 35	f'cr = f'c + 8
f'c > 35	f'cr = 1.1 f'c + 5

(*Source: SNI 2847-2013*)

5. Determine the type of cement and aggregate used
   Determine the cement used as well as coarse aggregate and coarse aggregate whether the type of crushed or uncrushed stone.
6. Determine the cement water factor
   - Determine the compressive strength at 28 days based on the type of Portland cement and coarse aggregate and the compressive strength test plan using table 3.4 for w/c 0.5 based on the cement and aggregate used.
   - Draw a straight line at a w/c ratio of 0.5 on the graph, until it intersects the specified compressive strength curve.
   - Draw a horizontal line based on the compressive strength obtained from the drawing, until it intersects the perpendicular line for w/c 0.5 then draw a new curve.
   - Draw a horizontal line from the new curve, with the targeted compressive strength value until it intersects the new curve, then draw the line down to get the cement water factor value.

Table 3.4 Estimated compressive strength (MPa) of in Indonesia

Type of cement	Type of Coarse Aggregate	Compressive Strength (MPa)				
		At the age (days)				Shape
		3	7	28	29	Shape of Specimen
Portland Cement type I	Uncrushed stone	17	23	33	40	Cylinder
	Crushed stone	19	27	37	45	
Sulphate Resistance Cement Type II. V	Uncrushed Stone	20	28	40	48	Cube
	Crushed stone	25	32	45	54	
Portland Cement Type III	Uncrushed stone	21	28	38	44	Cylinder
	Crushed stone	25	33	44	48	
	Uncrushed stone	25	31	46	53	Cube
	Crushed stone	30	40	53	60	

(*Source: SNI 03-2834-2000*)

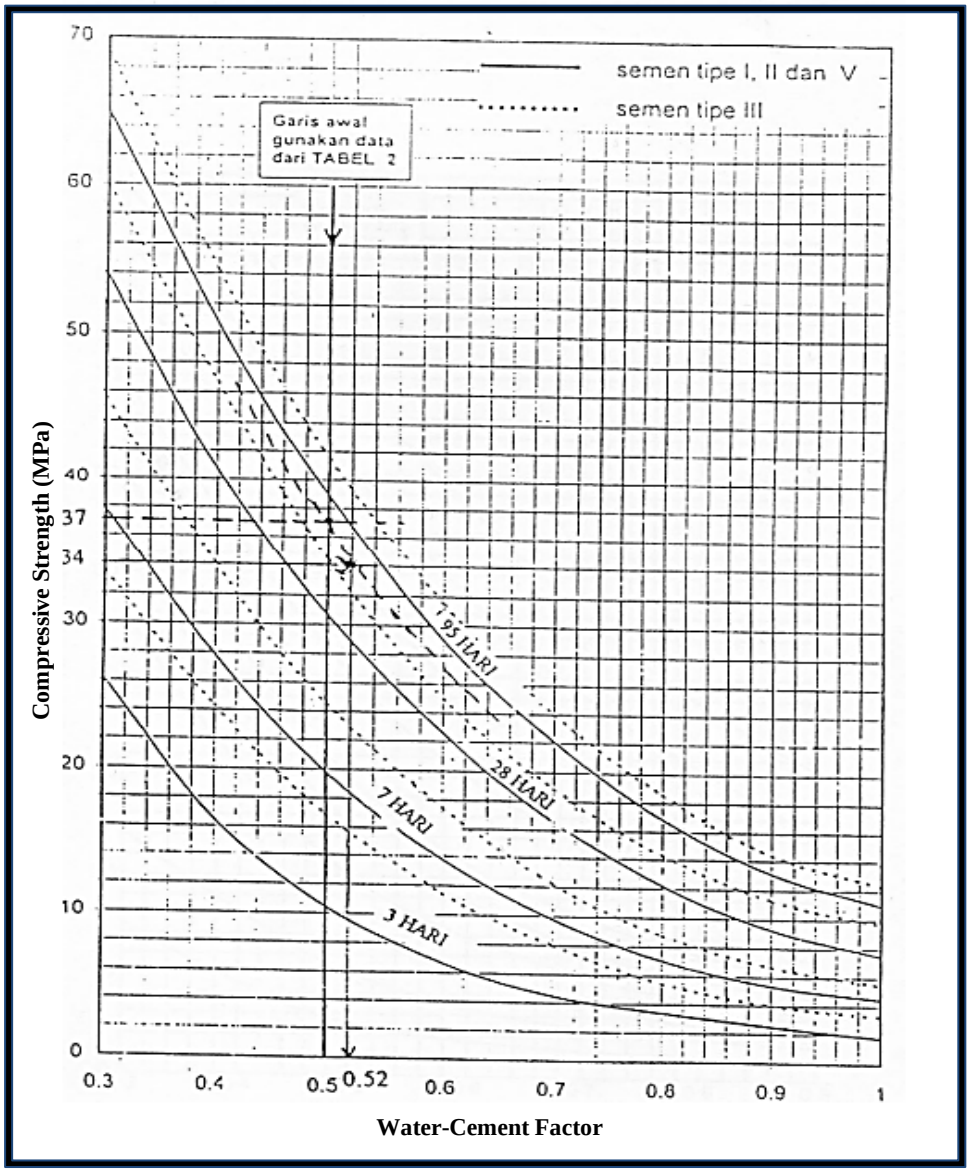

Figure 3.2 Graph of the relationship between compressive strength and W/C (Cylinder diameter 150 mm, length 300 mm)
(*Source: SNI 03-2834-2000*)

7. Determine the maximum water-cement factor (w/c) based on the table, for special environments using table 3.5. The water-cement factor value obtained from the sixth and seventh steps is the lowest value chosen.

Table 3.5 Requirements for the minimum cement and maximum W/C factor

Location	Minimum Cement Amount Per m^3 of Concrete (kg)	Maximum Water Cement Factor Value
Indoor concrete: a) Corrosive surrounding b) Non-corrosive surrounding caused by condensation and corrosive vapor	275 325	0.60 0.52
Outdoor concrete: a) Unprotected from rain and direct sunlight b) Protected from rain and direct sunlight	325 275	0.60 0.60
Concrete into the ground: a) Experiences wet and dry alternately b) Under the influence of sulfate and alkali from the soil	325	0.55 See table 5
Continuous concrete related: a) Water b) Salt water		See table 6

(*Source: SNI 03-2834-2000*)

8. Set slump value
   Determine the slump based on the conditions of work execution in order to obtain easy concrete.
9. Sets the maximum aggregate detail size
   The maximum aggregate grain size cannot be:
   - Exceeds 1/5 of the least distance between the side planes of the print
   - Exceeds 1/3 of plate thickness.
   - Exceeds 3/4 of the minimum clearance
10. Determine the free water content based on table 3.6

Table 3.6 Estimated free water content (kg/m^3) required

Slump		0-10	0-30	30-60	60-80
Aggregate grain size maximum	Type of aggregate				
10	Uncrushed aggregate	150	180	205	225
	Crushed aggregate	180	205	230	250
20	Uncrushed aggregate	135	160	180	190
	Crushed aggregate	170	190	210	225
40	Uncrushed aggregate	115	140	160	175
	Crushed aggregate	155	175	190	205

(*Source: SNI 03-2834-2000*)

Mixed aggregates are crushed and uncrushed, calculated using the formula:

$$2/3W_h + 1/3W_k \quad \text{..... 3.5}$$

Where:

W_h = Approximate amount of fine aggregate water

W_k = Approximate amount of water coarse aggregate

11. Calculate the amount of cement by dividing the free water content by the water cement factor.
12. If the maximum amount of cement is not set, then it can be ignored.
13. Determine the minimum amount of cement based on the table.
14. Determining the water-cement factor is adjusted to the amount of cement that changes because it is less than the minimum amount set or greater than the maximum amount of cement required, the water-cement factor must be recalculated.
15. Determine the arrangement of fine aggregate grains
16. Determine the arrangement of coarse aggregate if more than one type of coarse aggregate is combined
17. Determine the percentage of sand based on known values, namely the slump value, water-cement factor, and maximum aggregate nominal size using a graph

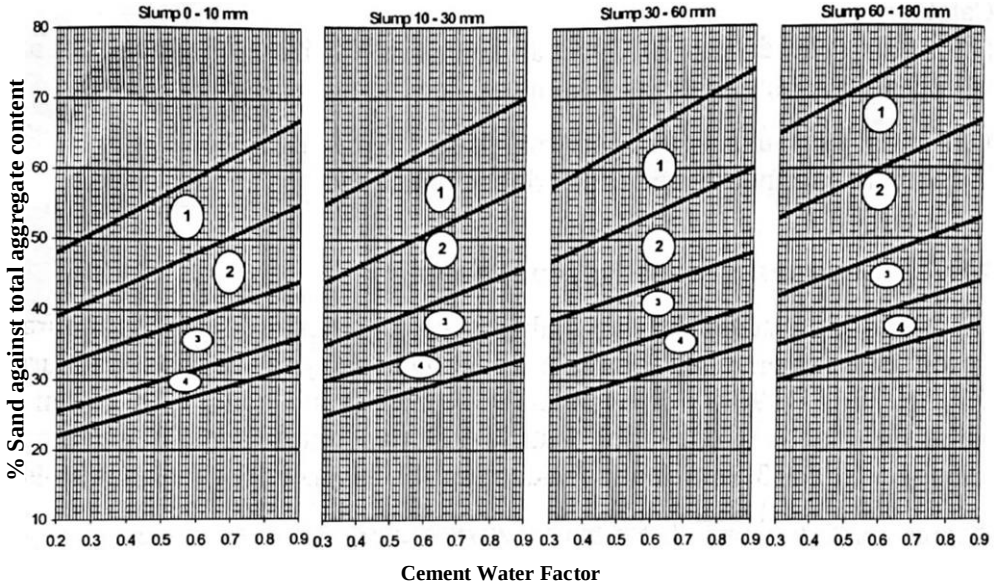

Figure 3.3 Percent of sand for a maximum grain size of 10 mm
(*Source: Mulyono, 2003*)

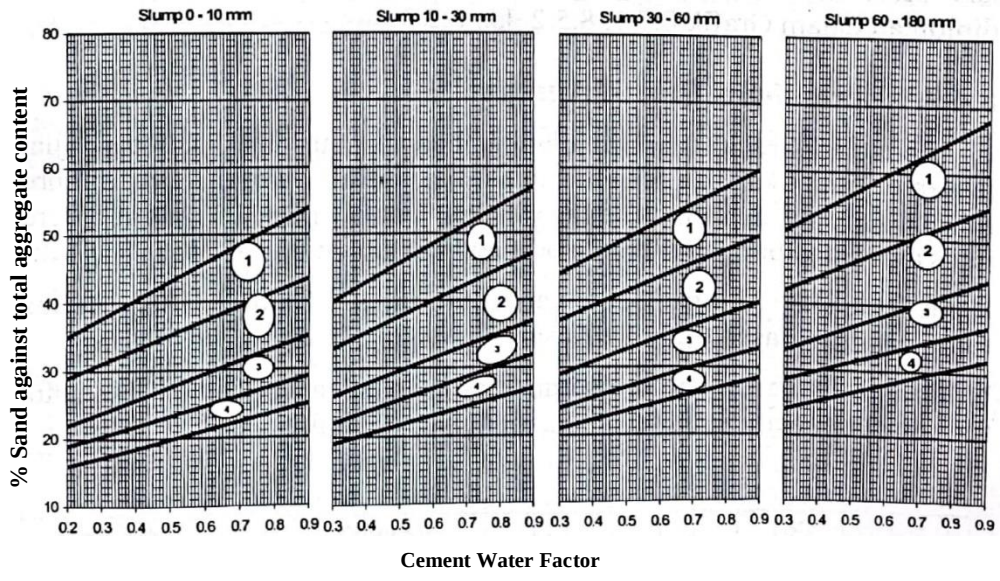

Figure 3.4 Percent of sand for a maximum grain size of 20 mm
(*Source: Mulyono, 2003*)

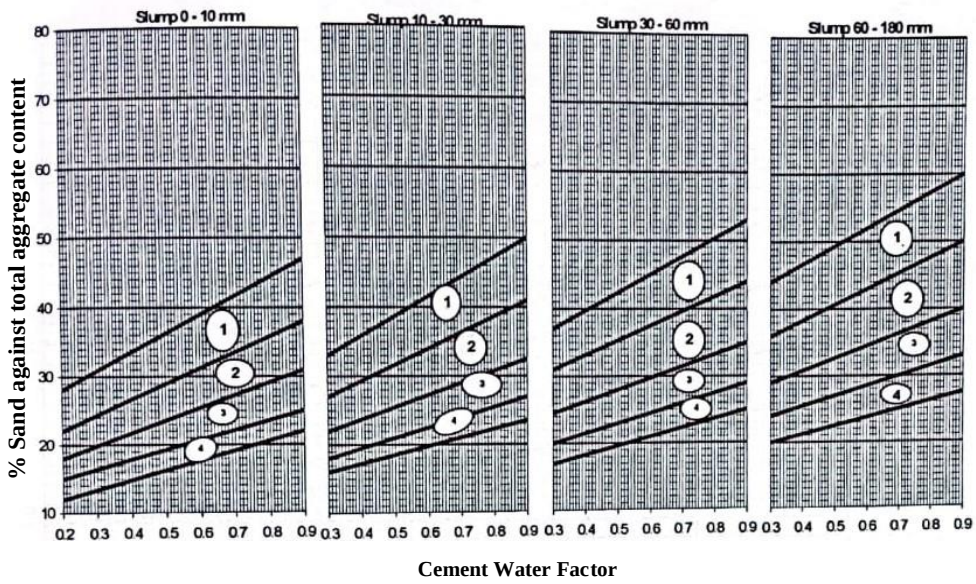

Figure 3.5 Percent of sand for a maximum grain size of 40 mm
(*Source: Mulyono, 2003*)

18. Combined grade. Graphics of the combined grade provisions of fine aggregate and coarse aggregate are following:

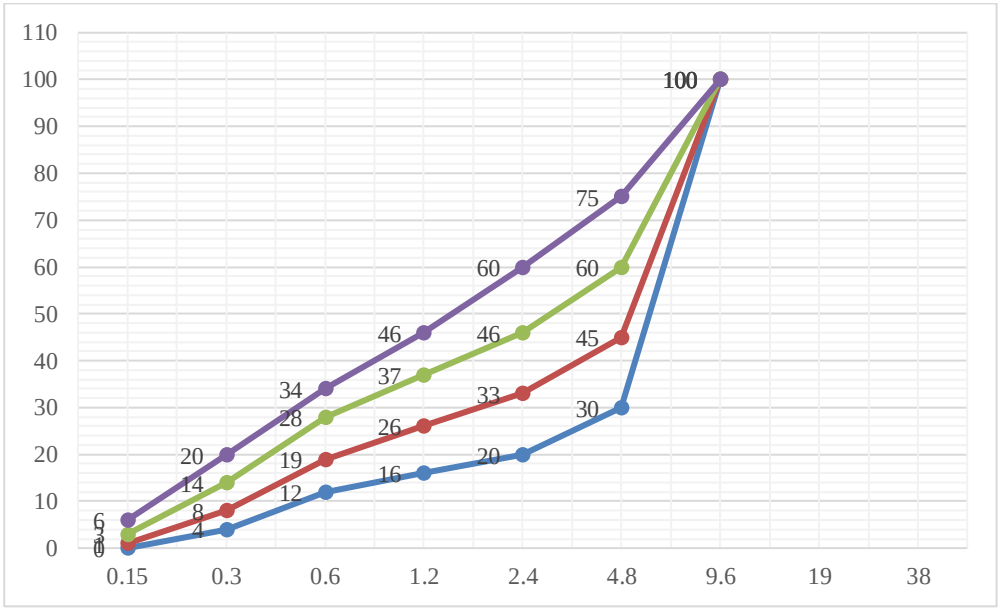

Figure 3.6 Graphic of combined grading, max grain size 10 mm
(*Source: SNI 03-2834-2000*)

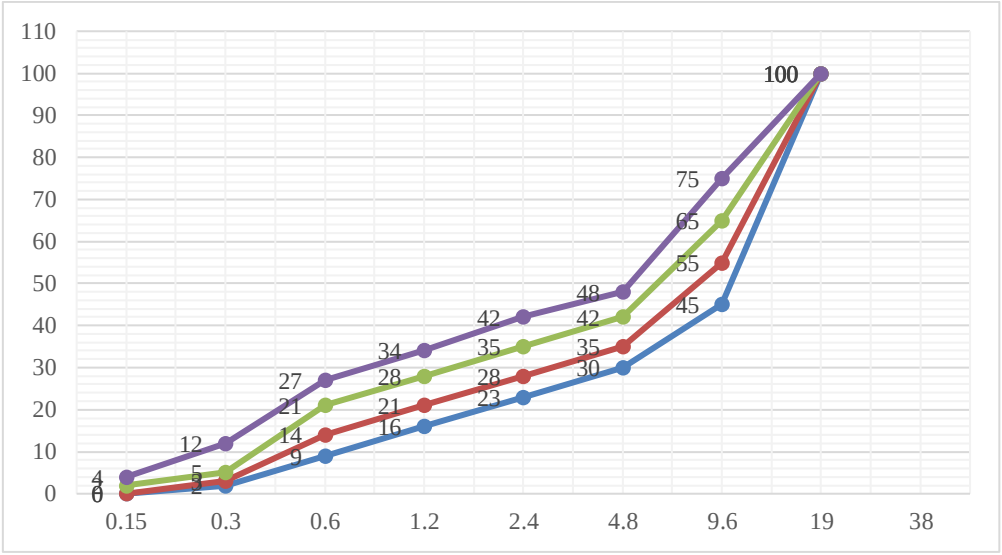

Figure 3.7 Graphic of combined grading, max grain size 20 mm
(*Source: SNI 03-2834-2000*)

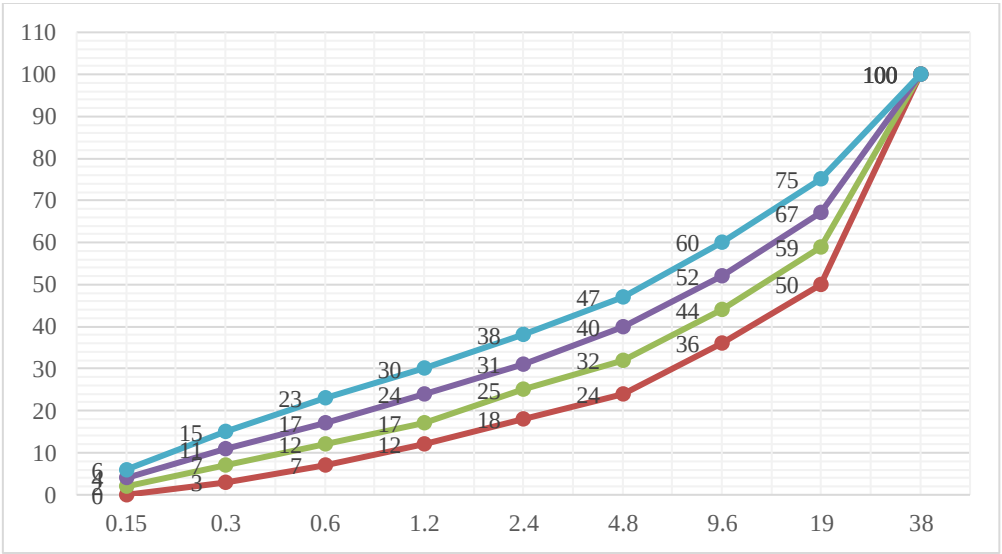

Figure 3.8 Graphic of combined grading, max grain size 40 mm
(*Source: SNI 03-2834-2000*)

19. Calculate the relative density of the aggregate
    Combined aggregate relative density = (% fine aggregate x relative density of fine aggregate) + (% coarse aggregate x relative density of coarse aggregate)
20. Determining the unit weight of concrete based on the value of the unit weight of the combined aggregate and free water content.

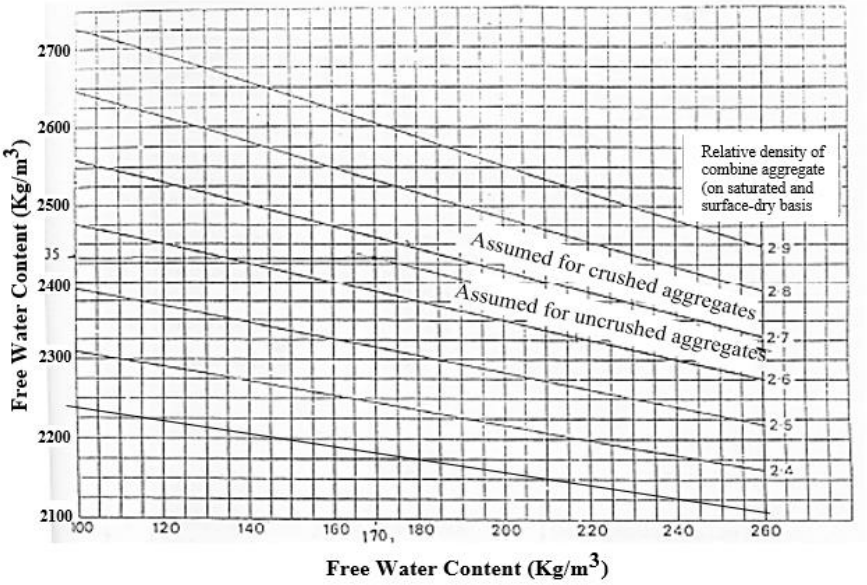

Figure 3. 9 Approximate content weight of finished compacted wet concrete (*Source: SNI 03-2834-2000*)

21. Calculating the combined aggregate content is obtained by reducing the concrete relative density with the free water content and cement content.
22. Calculating the content of fine aggregate obtained from multiplying the percent of sand grains with combined aggregate.
23. Calculating the content of coarse aggregate obtained from combined aggregate minus fine aggregate.
24. Correction of the composition of the concrete mix

    The composition of the mixture must be corrected for the water content in the aggregate if the aggregate is not in a dry saturated state. The following is the correction formula for the composition of the concrete mix:

    Water = $B - (C_k - C_a) \times C/100 - (D_k - D_a) \times D/100$

    Fine Aggregate = $C + (C_k - C_a) \times C/100$

    Coarse Aggregate = $D + (D_k - D_a) \times D/100$

    Where:

    B = Amount of water

    C = Amount of fine aggregate

    D = Amount of coarse aggregate

    C_a = Absorption of fine aggregate (%)

    D_a = Absorption of coarse aggregate (%)

    C_k = Water content of fine aggregate (%)

    D_k = Gross aggregate water content (%)

3.7 Test Specimen Planning

This study used two types of cylinders, namely a cylinder with a height of 300 mm and a diameter of 150 mm was used for compressive strength testing, and a cylinder measuring 200 mm in length and 100 mm in diameter was used for testing water infiltration. Coarse aggregate proportion planning using dead coral as much as 0%, 25%, 50%, 60% and 75% is presented in the following table.

Table 3.7 Sample specimens of concrete with coral as coarse aggregate

Test Specimen	Crushed Gravel	Dead Coral	Compressive strength Samples		Absorption Samples
			14 days	28 days	
BK0	100%	0%	3	3	2
BK25	75%	25%	3	3	2
BK50	50%	50%	3	3	2
BK60	40%	60%	3	3	2
BK75	25%	75%	3	3	2
∑Sample			30		10
			40		

(*Source: Author, 2024*)

3.8 Concrete Casting

The stages of casting concrete are as follows:

1. Prepare the necessary equipment and materials
2. Filling the mixer with a little water aims to just wet the mixer.
3. Enter all the coarse aggregate and enter 3/4 of the amount of water.
4. Add cement after all the coarse aggregate is wet evenly.
5. After the cement has adhered evenly to the gravel, then add sand.
6. It is expected to check the concrete mixture in the mixer whether the water is enough or not enough. Add the rest of the water if it's not enough.
7. The concrete mixture can be removed from the mixer and accommodated in the mixing tub after the concrete mixture is homogeneous.

3.9 Concrete Test

In this study, research was carried out on fresh concrete, namely concrete mixes whose characteristics have not changed or are still plastic and no binding has occurred. And also done on hard concrete which is concrete that has hardened.

3.9.1 Fresh Condition Test

1) Slump Test
   - Purpose of Test
     The slump test is carried out to measure workability, and uniformity of water use is obtained.
   - Material used
     Fresh concrete
   - Equipment used
     - Steel cone tube (Abraham tube)
     - The hammer/piercing tool is made of iron with a diameter of 16 mm and a length of 60 cm
     - Ruler
     - Steel plate
   - Step of test
     - Moisten the inside of the cone and set it on the table.
     - Incorporate fresh concrete into the cone gradually, 1/3-part I, II, and III every part pounded 25 times. Especially for the impact on the first layer of collision, it cannot penetrate the armor plate.
     - Leveling the surface of the concrete cone after the cone is full.
     - Measure the height of the cone as the initial height of the concrete.
     - Slowly lift the cone vertically then hold it for 30 seconds.
     - Measure the height of the concrete after the cone is lifted as the final height.
     - Calculating the slump value using equation (2.15)
2) Unit Weight Test
   - Purpose of Test
     The purpose of this test is to determine the unit weight of concrete
   - Material used
     Fresh concrete
   - Equipment used
     - Balance
     - Water tank
   - Step of Test
     - Weighing concrete specimens
     - Calculate the volume of the test object
     - Calculating the amount of relative density using the formula (2.16)

3.9.2 Hard Condition Test

1) Absorption Test
   - Purpose of Test
     Absorption test is carried out to determine the water absorption capacity of concrete
   - Material used
     Hardened concrete 10 x 20 cm
   - Equipment used
     - Balance
     - Water tank
   - Step of test
     - Soaking the test object in clean water for 24 hours.
     - Remove the test object after 24 hours, then leave it for ± 1 minute and then wipe the surface using a dry cloth in order that it reaches a dry surface.
     - Weigh the test object after soaking and then record it
     - Put the test object into the oven for 24 hours with an oven temperature of 110 ºC.
     - After the oven then weigh the test object and record the weight.
     - Calculating using equation (2.17)
2) Compressive Strength
   - Purpose of Test
     The purpose of this test is to determine the compressive strength of concrete
   - Material used
     Hardened concrete 15 x 30 cm
   - Equipment used
     - Balance
     - Compressive machine
   - Step of Test
     - Weighing the concrete test object to obtain the unit weight.
     - Level the concrete surface using the available tools, if the concrete surface is uneven.
     - Placing the test object on the compressive strength machine
     - Turn on the compressive strength machine in order that the test object gets the load. The test was stopped after specimen destroyed.

- Record the maximum load that occurs during the test.
- Take the test object from the press machine.
- Calculating the compressive strength of the test object using equation (2.18).