3. Experimental program

3.1 Materials Properties

The Sudanese materials that were used for polypropylene Fiber Reinforced Concrete (PpFRC) throughout the experimental work are : Cement, Aggregate: sand and gravel, Water and Polypropylene Fiber , all tests were done in concrete laboratory in Gezira university. Sudan.

3.1.1 Cement

Cement is an organic material that sets and develops strength by chemical reaction with water by formation of hydrates.

Figure (34): ordinary Portland cement O.P.C.

- In this research, a locally produced ordinary Portland cement type I, conforming to (American Society for Testing and Materials C150 (Ordinarily Portland Cement 42.5N): Sudan Rock which is extensively used in Sudan.

3.1.2 Aggregate

Aggregate is Granular materials, it classified to crushed stone and un crushed (Natural), used with cementing medium to form concrete. It has main parts of the concrete that constitute the bulk of the finished product. They comprise 60-80% of the volume of the concrete and have to be so graded that the entire mass of concrete acts as act as a relatively inexpensive inert filler, providing stability against volume changes and influencing strength and stiffness, homogeneous and dense. Aggregate must be: Soundness, gradual, clean, good and acceptable service area and shape Presence of Clay lumps, sulfate or chloride ions and organic

Impurities in Aggregate. The aggregate is usually split into at least two different portions for ease of batching. The common dividing point is 5mm (or 4.75mm).

Types of Aggregate:

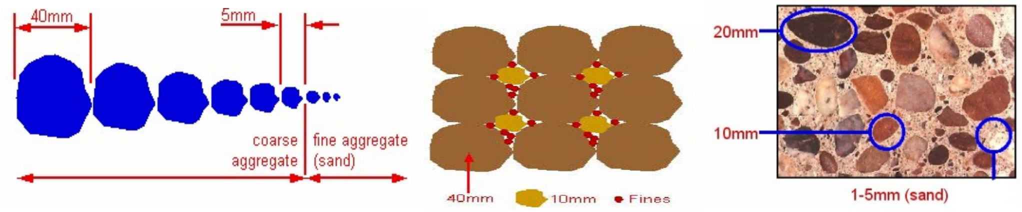

Figure (35): Type of aggregate with partition limit size, important of Gradual Aggregate.

- **Coarse Aggregates**:

  The material larger than 5mm is termed coarse aggregate or gravel.

  - In these research un crushed Coarse Aggregates of size 20 mm graduated used supply them from Elgailee (Khartoum).

Figure (36): Coarse Aggregate.

- **Fine Aggregate**

  The material smaller than 5mm is termed fine aggregate or sand.

  - In this research sand used supply collection from Ganeeb Elasad (Wad Medani) and Knger (Khartom) by 1:1 ratio.

Figure (37): Fine Aggregate.

3.1.3 Water

Drinking water is suitable to concrete required. It reacts with the cement to give concrete: permeability, cohesion, adhesion, strength and other properties with in other component of concrete. Water must be suitable for drinking is usually good enough for concrete free of all organic matter and certain chemicals such as alkaline and sulfate salts.

Figure (38): Water of concrete.

3.1.4 Polypropylene Fiber

Polypropylene Fiber is one of the Synthetic fiber reinforcement which is available in one cubic yard (one cubic meter) Polypropylene fiber is short-cut strands of very fine fiber. It has many advantage which are described an chapter two also it have many method of adding depend on the percentage of volume add .The fibers were supplied by PYCHEM Co.LLC Industry for middle east and north Africa by name AdfiBRE' III:3D Poly propylene fiber reinforcement.

AdFIBRE' III is a fiber reinforcing material which admixture to concrete , shotcrete , mortar at the mixing stage, millions of fibers are dispersed and distributed homogeneously throughout the batch .It is available in 3 standard length size : 6mm,12mm and 19 mm .In the present investigation 12mm fiber length is used with standard compliance (American Society for Testing and Materials– 1116).

- The Data sheet of Polypropylene Fiber was attached in appendices

Figure (39): Polypropylene Fiber.

Table (4): Physical and chemical properties of Polypropylene fiber (AdFIBRE' III)) PYCHEM Co.LLC Data sheet).

Material	Virgin HomopolymerPolypropylene
Shape of fiber	Monofilament
Length of fiber	12 mm
Diameter	18 micron normal
Specific Gravity	0.91
Melting Point	162^o C , above
Absorption	Nil
Acid and resistance	99% Strength retained
Alkali resistance	99%Strength retained (40%NaOH solution at 21^o C for 1100 hrs).
Tensile strength	3500 – 7700 Kg/m^2 , above
Young's modulus	35 * 10^3 Kg/m^2 , above

- Generally, Polypropylene is an economic and available in Sudan. 1 page of Polypropylene Fiber have 900g which is approximately the lower percentage in these research 0.05% volume or 1.19 kg/m^3 of concrete which bought by (85 – 100) SDG.

3.2 Methods

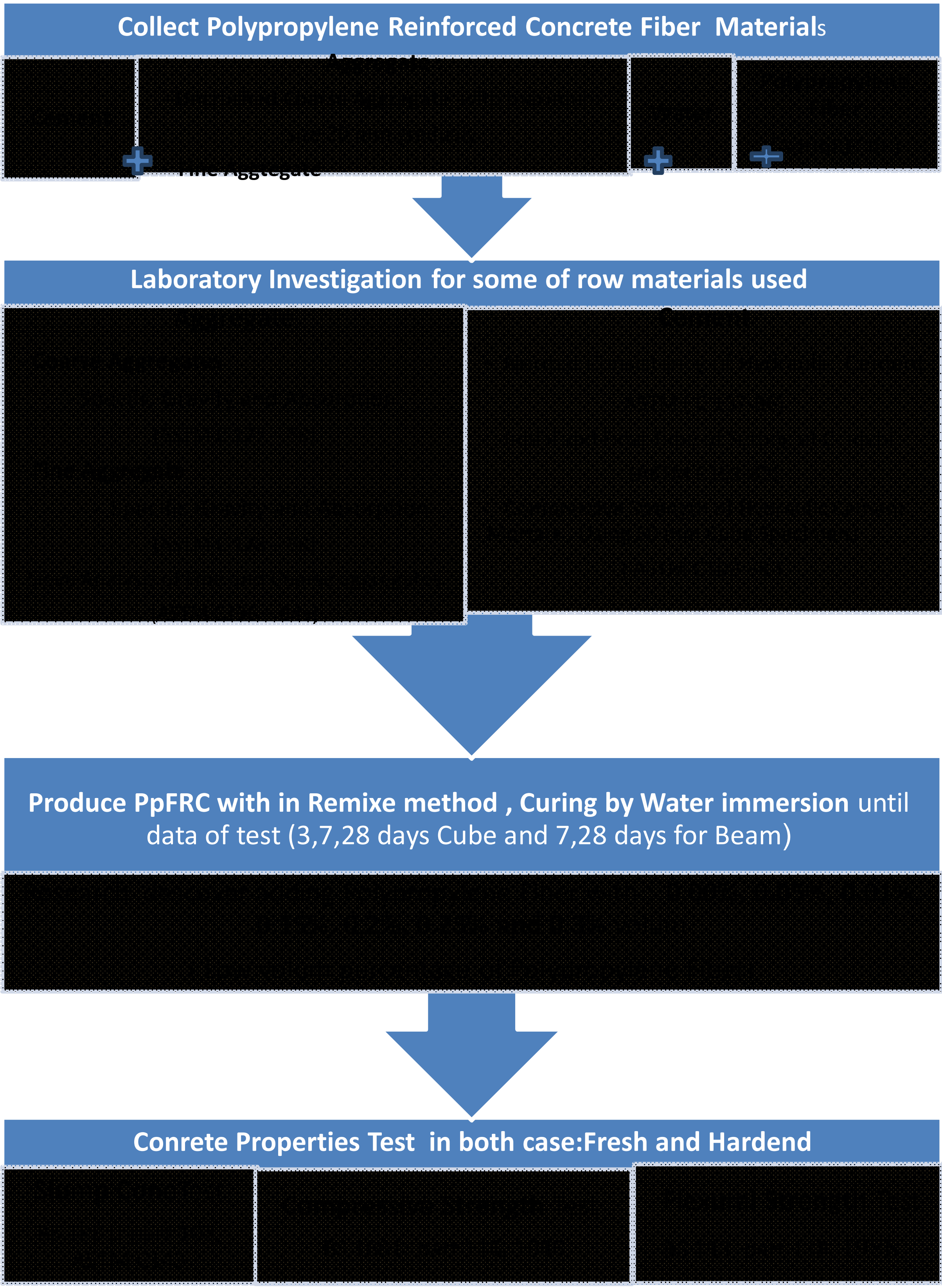

Figure (40): Expremental program step by step.

3.2.1 Test of Row Materials

Prepare laboratory samples and clean machine for all test.

- Al Row material from Sudan resource .
- All Tests was done in the concrete laboratory, Gezira University, Sudan.

3.2.1.1 Aggregate Test

Sampling aggregates for concrete is usually based on random selection with each part of the stock pile having an equal chance of being sampled. In laboratory, the sample is reduced to an appropriate size using a riffle box or a quartering board.

Figure (41): The sample splitters for fine and coarse aggregates and Reducing Field Sample of Aggregate to Test Sample.

3.2.1.1.1 Specific Gravity and Absorption of Coarse Aggregate.

Scope:

This test method covers the determination of Specific Gravity and Absorption of coarse aggregate. The specific gravity may be expressed as bulk specific gravity, bulk specific gravity SSD or apparent specific gravity. The bulk specific gravity and absorption are based on aggregate after 24hour soaking in water.

Table (5): Nominal maximum size (NMS) of the coarse aggregate

N.M.S (mm)	Minimum Weight of Sample
12.5 or less	2
19	3
25	4
37.5	5
50	6

1-Specific Gravity:

a. Bulk specific gravity: Calculate the bulk specific gravity as follow:

Bulk Specific Gravity = A / (B-C)

Where:

A=Weight of oven-dry test sample in air, (g)

B= Weight of S.S.D. sample in air, (gm).

C=Weight of saturated sample in water, (gm).

b- Bulk Specific Gravity (SSD) = B / (B-C)

C-Apparent Specific gravity: Calculate the apparent sp. gr. As follows:

Apparent Specific Gravity = A / (A - C)

2- Absorption:

Calculate the percentage of absorption as follows:

Absorption%= [(B – A) / A] x100

- **Note:** According to (American Society for Testing and Materials C 127 – 88).

Figure (42): A balance with suitable apparatus for suspending the sample container in water.

3.2.1.1.2 Specific Gravity and Absorption of fine Aggregate

Scope:

This test method covers the determination of Bulk and Apparent Specific Gravity and Absorption of fine aggregate.

Calculations: Calculate the bulk specific gravity as follows:

Bulk sp. gr. = A / (B + S – C)

Where:

A: Weight of oven dry specimen in air, (gm).

B: Weight of pycnometer filled with water, (gm).

S: Weight of the saturated surface-dry specimen, (500 gm).

C: Weight of pycnometer with specimen and water to calibration mark, (gm).

1 - Calculate the bulk specific gravity (SSD) as follows:

Bulk sp. gr. (SSD) = S / (B + S – C)

2- Calculate the apparent Specific Gravity as follows:-

Apparent sp. gr = A / (B + A - C)

3 - Calculate the percentage of absorption as follows:-

Absorption = [(S – A) / A x] 10

- **Notes**: According to (American Society for Testing and Materials C 128 – 88).

Figure (43): Exposing the fine aggregate to a gently moving current of warm air.

Figure (44): The fine aggregate is still damp.

Figure (45): The fine aggregate is in SSD condition.

3.2.1.1.3 Sieve Analysis of fine and coarse aggregates

Scope:

This method covers the determination of the particle size distribution the fine and coarse aggregate by sieving.

Table (6): Minimum weight of test sample of fine aggregate.

N.M.S (mm)	Minimum Weight of Sample (Kg)
9.5	1
12	2
19	5
25	10
37.5	15

Table (7): Sieves dimensions are:

No of sieve	100	50	30	16	8	4	3/8"	1/2"	3/4"	1"	1.5"
Size of opening (mm)	0.150	0.300	.0600	1.18	2.36	4.75	9.50	12.5	19	25.40	37.50

Table (8): The results must be compared with ASTM Specification for Fine aggregate.

Sieve No	Sieve size (mm)	% Pasing
3/8"	9.5	100
No.4	4.75	95 –100
No.8	2.36	80 –100
No.16	1.18	50 –85
No.30	0.600	25 –60
No.50	0.300	5 –30
No.100	0.150	0 –10

Table (9): The results must be compared with ASTM Specification for Coarse aggregate.

TABLE 2 Grading Requirements for Coarse Aggregates

Size Number	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square-Openings), Mass Percent													
		100 mm (4 in.)	90 mm (3½ in.)	75 mm (3 in.)	63 mm (2½ in.)	50 mm (2 in.)	37.5 mm (1½ in.)	25.0 mm (1 in.)	19.0 mm (¾ in.)	12.5 mm (½ in.)	9.5 mm (⅜ in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	1.18 mm (No. 16)	300 µm (No.50)
1	90 to 37.5 mm (3½ to 1½ in.)	100	90 to 100	...	25 to 60	...	0 to 15	...	0 to 5	...	...	...	...	...	...
2	63 to 37.5 mm (2½ to 1½ in.)	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...	...
3	50 to 25.0 mm (2 to 1 in.)	...	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...
357	50 to 4.75 mm (2 in. to No. 4)	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	...	0 to 5	...	...	...
4	37.5 to 19.0 mm (1½ to ¾ in.)	...	...	...	...	100	90 to 100	20 to 55	0 to 15	...	0 to 5	...	...	...	...
467	37.5 to 4.75 mm (1½ in. to No. 4)	...	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	0 to 5	...	...	...
5	25.0 to 12.5 mm (1 to ½in.)	...	...	...	...	...	100	90 to 100	20 to 55	0 to 10	0 to 5	...	...	...	...
56	25.0 to 9.5 mm (1 to ⅜ in.)	...	...	...	...	...	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	...	...	...
57	25.0 to 4.75 mm (1 in. to No. 4)	...	...	...	...	...	100	95 to 100	...	25 to 60	...	0 to 10	0 to 5	...	...
6	19.0 to 9.5 mm (¾ to ⅜ in.)	...	...	...	...	...	...	100	90 to 100	20 to 55	0 to 15	0 to 5	...	...	...
67	19.0 to 4.75 mm (¾ in. to No. 4)	...	...	...	...	...	...	100	90 to 100	...	20 to 55	0 to 10	0 to 5	...	...
7	12.5 to 4.75 mm (½ in. to No. 4)	...	...	...	...	...	...	...	100	90 to 100	40 to 70	0 to 15	0 to 5	...	...
8	9.5 to 2.36 mm (⅜ in. to No. 8)	...	...	...	...	...	...	...	...	100	85 to 100	10 to 30	0 to 10	0 to 5	...
89	9.5 to 1.18 mm (⅜in. to No. 16)	...	...	...	...	...	...	...	...	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5
9[A]	4.75 to 1.18 mm (No. 4 to No. 16)	...	...	...	...	...	...	...	...	...	100	85 to 100	10 to 40	0 to 10	0 to 5

[A] Although size 9 aggregate is defined in Terminology C 125 as a fine aggregate, it is included as a coarse aggregate when it is combined with a size 8 material to create a size 89, which is a coarse aggregate as defined by Terminology C 125.

- **Notes**: According to (American Society for Testing and Materials C136 – 84a).

Figure (46): The Mechanical Sieve Shaker.

3.2.1.2 Cement Tests

3.2.1.2.1 Normal Consistency of Hydraulic Cement

Scope:

This test method covers the determination of the normal consistency of hydraulic cement. That is by determining the amount of water required to prepare cement pastes for Initial and final time of setting test.

- **Note**: According to (American Society for Testing and Materials C 187-86).

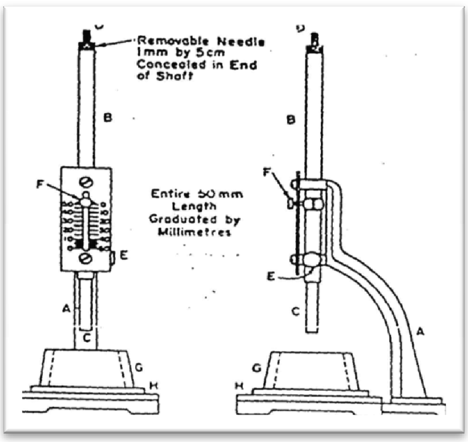

Figure (47): The Vicat apparatus.

3.2.1.2.2 Initial and Final Time of Setting of Cement

Scope:

This test covers determination of the time of Setting of cement by means of the Vicat needle.

- **According to ASTM C150**
  Initial time of setting, not less than 45 min.
  Final time of setting, not more than 375 min.
- **Note**: According to (American Society for Testing and Materials C191-82).

3.2.1.2.3 Compressive Strength of Hydraulic Cement Mortars

Scope:

This test method covers determination of the compressive strength of cement mortars, using (50 mm) cube specimens.

Calculations:

1-Table the results.

2- Compare with (American Society for Testing and Materials C150-89): σc ≥ 19.3 MPa [For type O.P.C cement] age 7 days.

2- Compare with (American Society for Testing and MaterialsC150-89): σc ≥ 42.5 MPa [For type O.P.C cement] age 28 days such as in data sheet or bags.

- **Note**: According to (American Society for Testing and Materials C109-88).

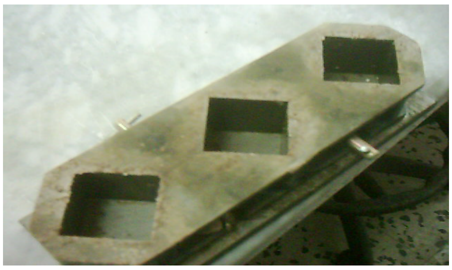

Figure (48): The specimens molds.

3.2.2 Fresh and Hardened Concrete Test

Produce PpFRC with in Re mix method, Curing by Water immersion until data of test (3, 7, 28 days Cube and 7, 28 days for Beam.

3.2.2.1 Slump cone test:

The slump test is the most commonly used method. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It is used for the determination of the consistency of freshly mixed concrete, where the maximum size of the aggregate does not exceed 38 mm. The slump test is suitable for slumps of medium to high workability, slump in the range of 25 – 125 mm; the test fails to determine the difference in workability in stiff mixes which have zero slumps, or for wet mixes that give a collapse slump. It is used to indicate the degree of wetness. It is also used to determine consistency between individual batches. The apparatus used for conducting the slump test consists of slump cone or Abrams cone with handles and foot pieces. The size of the slump cone is 20-cm diameter base, 10 cm diameter top and 30 cm height. Foot pieces can be fixed to the clamps on the base plate. The base plate has lifting handle for easy transportation. The internal surface of the mould is thoroughly cleaned and free from moisture and adherence of any old set concrete before commencing the test. The mould should be placed on smooth surface.

The types of slump are as follows:

- **Collapse**: In a collapse slumps the concrete collapses completely.
- **Shear**: In a shear slump the top portion of the concrete shears off and slips sideways.
- **True:** In a true slump the concrete simply subsides, keeping more or less to shape.

- Note: According to (British Standard 1881: part 102, American Society for Testing and Materials C143).

3.2.3 Testing of hardening concrete:

3.2.3.1 Compressive Strength of Concrete:

Concrete cubes of 150 X 150 X 150 mm dimension were casting for compressive strength. They have tested for compressive strength after 7, 14and 28 days of water curing, the compressive strength of concrete is used as the most basic and important material property when reinforced concrete structures are designed. It has become a problem to use this value, however, because the control specimen sizes and shapes may be different from country to country.

The ultimate strength of concrete is influenced by the water-cementitious ratio (w/cm), the design constituents, and the mixing, placement and curing methods employed. All things being equal, concrete with a lower water-cement (cementitious) ratio makes a stronger concrete than that with a higher ratio.

Strength tests are required for to check the potential strength of the concrete under controlled conditions against the desired strength, also to establish a strength-age relationship for the concrete under job conditions as a control for construction operations or the opening of the work.

Calculations:

Compressive strength = load/ Area = P/A (N/mm2).

- Note: According to British Standard 1881: part 116, 1986.
- In this research, tested were done at 3,7,28 days 9 cubs for each percentage from 7 percentage which were tested that is mean we have 63.

3.2.3.2 Flexural Strength Test:

Flexure strength is one of the measures of tensile strength of concrete. It is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced concrete beams with a span three times the depth. The flexural strength is expressed as "Modulus of Rupture" (MR) in psi. Flexural MR is about 12 to 20 percent of compressive strength. However, the best correlation for specific materials is obtained by laboratory tests.

The load was applied by the downward movement of the platen without eccentricity, this load and displacement data were obtained for each beam specimen and the average values of replicate specimen were calculated.

These routine tests are usually made only on paving jobs and are tested at the job site. Rehabilitation projects requiring early openings may also utilize flexural tests. Were casting beam dimension (15omm *150mm*550mm) for flexural strength.

Calculations:

F_b= PL/ bd2

Where:

F_b= Flexural of beam

b = Width in cm of specimen

d = Depth in cm of specimen at point of failure

L = Length in cm of specimen on which specimen was supported

P = Maximum load in kg applied to specimen

- Note: According to British Standard 188: part 118, 1986.
- In this research, tested were done at 7,28 days 6 cubs for each percentage from 7 percentage which were tested that is mean we have 43.

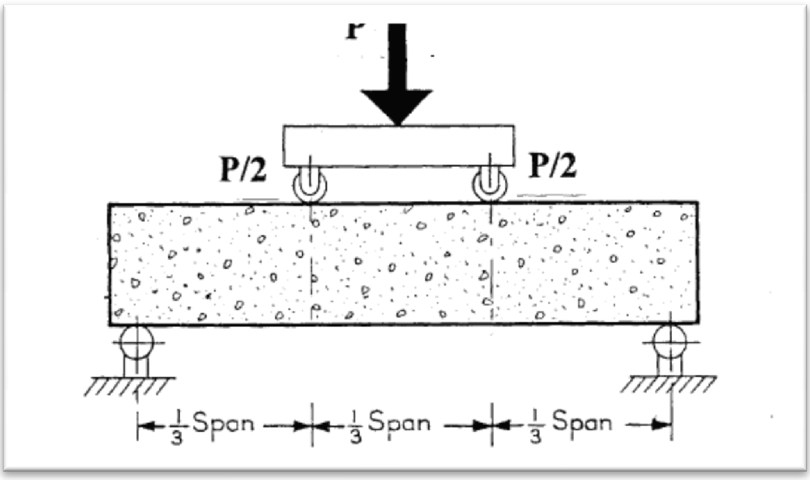

Figure (49) : Flexure Strength Test.