TVET CERTIFICATE V in ROAD CONSTRUCTION

RCTCT501

COMPRESSION TEST

PERFORM COMPRESSION TEST

Competence

Learning hours: 30

REQF Level: 5
Credits: 3

Sector: Construction and Building Services
Sub-sector: Road construction

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Purpose statement

This module describes the skills, knowledge and attitudes required to Perform Compression test.

At the end of this module, participants will be able to prepare for works, apply compression strength determination procedures and interpret the results.

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Total Number of Pages: 24

Learning unit 1 – prepare for work.

1. Introduction to compression test

A compression test: is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, "squashed", crushed, or flattened.

The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten.

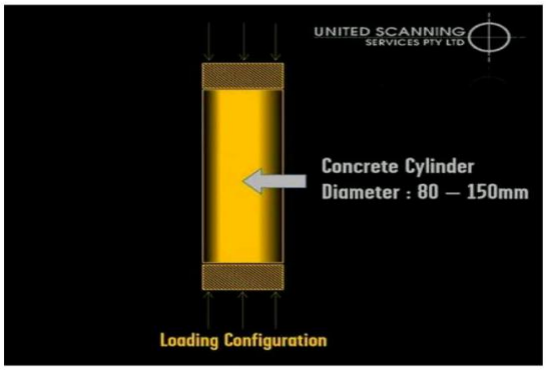
Compression tests are used to determine how a material or substance reacts when it is compressed, crushed, thus, data from the test are gathered through fundamental parameters emerging from the behaviour of the specimen under a compressive load.

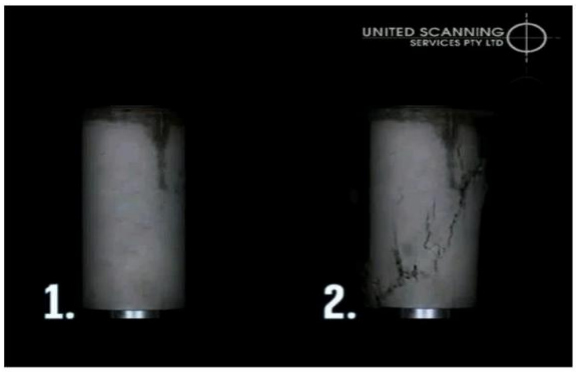
Types of compression testing

- **Flexure /bend:** this is more affordable than a tensile test and test result are slightly different. the material is laid horizontally over two points of contact (lower support span)and then a force is applied to the top of the material through either one or two point of contact (upper loading span)until the sample fail.

- **Spring testing:** this method, such as load and free length testing for a compression spring, are useful to analyses and improve the spring making processes. Spring performance testing commonly uses load/rate testing where the spring load and length are measured at 20%and 80%0f either the springs rated load or length.

- **Top-load crush :**this test involve placing a steadily increasing load down to the length of core sample until the sample fracture and break the load at which the concrete collapses indicate its compressive strength ,and from this can be calculated an array of useful information





PURPOSE OF COMPRESSION TESTS

The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables, such as, strain, stress, and deformation. By testing a material in compression the compressive strength, yield strength, ultimate strength, elastic limit, and the elastic modulus among other parameters may all be determined. With the understanding of these different parameters and the values associated with a specific material it may be determined whether or not the material is suited for specific applications or if it will fail under the specified stresses

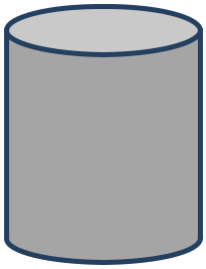
L.O 1.1 – interpret specifications of compression test

- Topic: Description of compression test machine.

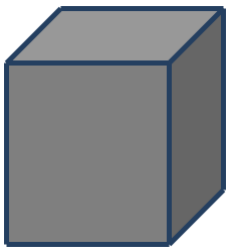
This Compression Testing Machine is a hydraulic, electrically operated unit, designed for conducting compression tests on concrete specimens up to 20 cm. Diameter (or width and depth) and 30 cm, in height and also rocks and various other materials.

But commonly we use is the cube of (15*15*15) cm and a cylinder of 15 cm of diameter and 30 cm of height.

30 cm



Φ 15 cm.



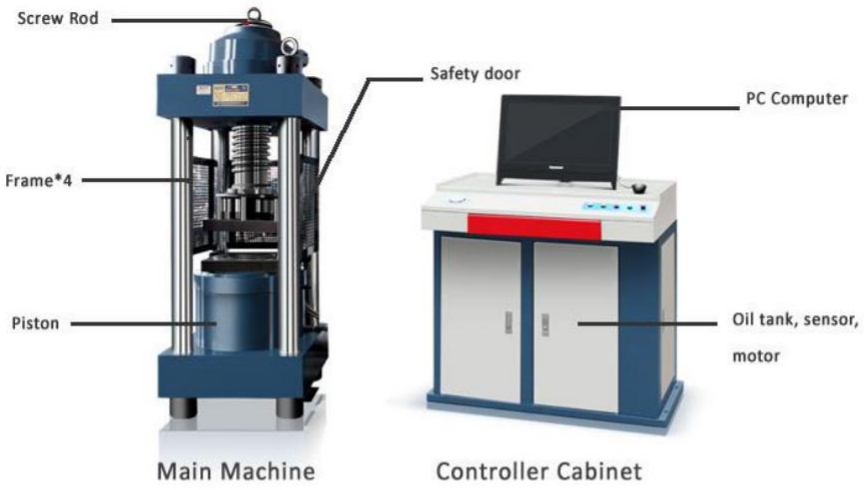
(15*15*15)cm

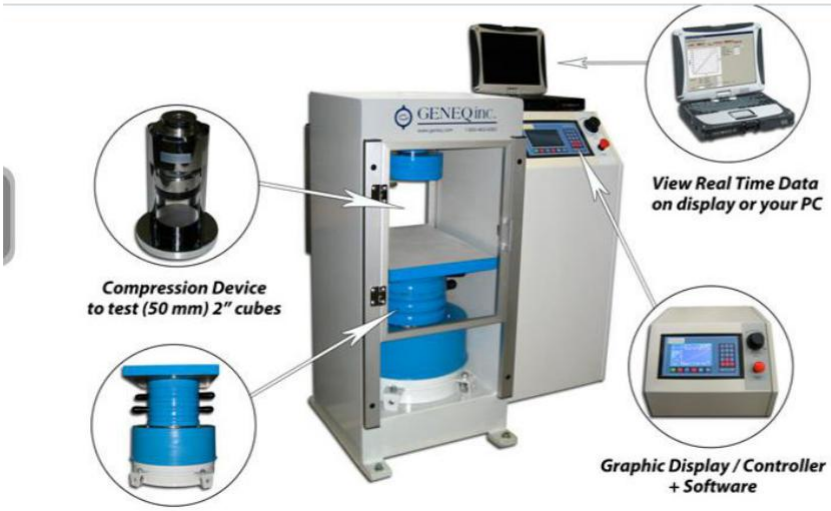
1.1.1. Components of Compression Testing Machine.

There a three main parts of a compression testing machine

A complete compression test machine encompasses the following components:

- **Compression Frame**- These are a heavy duty welded frame. Platens and distance pieces are also included in the frame, to adjust the system for different sample sizes.
- **Control System-** The control system is fully automated. This means that a macro is created containing the require loading rate, sample size etc. Once started the test is automatic. The data from the test is also logged in the control system.
- **Power pack-** this is a hydraulic two stage system with one motor to adjust the platens for rapid approach and another for the application of force during the test.





Full Automatic

1.1.2. General specifications of compression test machine:

- Single screw driver technology
- Power coater body with computer interfacing system and software
- Safety feature by limit switch operation

1.1.3. Technical specifications

Selecting a Compression Testing Machine

The compression machines have to be selected depending on the specimen strength, shape and dimensions. This requirement determines the capacity of the frame, the type of spherical seat and the platen dimension.

The other important feature is the power and control unit which refers not only to International Standard requirements on load application, strength measurement and accuracy, but also to the level of automation.

The following are the technical specification of the compression machine:

- Load capacity
- Maximum test speed
- Load accuracy
- Extension measuring lease-count
- Maximum cross head travel
- Display system
- Power requirement

1.1.4. Other aspect to be considered in section of compression machine

- **Frequency of use (number of tests per day**) is considered in order to choose the automatism level: obviously, a completely automatic machine allows a faster turnover.

- **Purpose of the tests**: if they are performed for simple checks, on an occasional basis, or for educational purposes, a hand-operated model may well represent a low-cost solution. Versatility of a machine is of vital importance for a research laboratory, which probably needs to test specimens with special characteristics. The reading system most commonly used nowadays is the digital readout which has replaced the classic analog dial gauge. Various forms of data processing become possible through the application of sensors and electronic control units. Data can be displayed in numeric form, printed or processed by a computer. In this last case the fully compiled certificate is obtained automatically.

- **Load capacity**: Refers to the maximum stress or load may be placed on designed sample under normal condition for an extended period of time.
  - **Maximum test speed**: compression test machine may have efficient and constant speed at right period of time which can crush the prepared sample
  - **Load accuracy**: indicate the correct load for crushing the prepared sample.
  - **Extension measuring lease-count**: used to read the force or load applied on sample
  - **Display system**
  - **Power requirements**

Load capacity	**1Kn**
Maximum test speed	500mm/min±1%
Load accuracy	±0.5% of readings
Extension measuring lease-count	0.001 mm
Maximum cross head travel	700mm
Display system	Digital LCD display system
Power requirements	Single phase ,230v ac, 50HZ

1.1.5. How to find the capacity of compressive machine

A compression tester machine uses a high oil pressure as a power source and exerts a relatively large force. Also, most of these machines are hydraulic and exerts a pressure that is significantly over 200KN. In a construction company, this machine is used to test materials like concrete, cement, bricks, rubber, and metals.

The Technical test range comprises machines of 1500, 2000, 3000, 4000 and 5000 kN capacities. Choice of machine is made according to size and strength of specimens to be tested in the laboratory.

For example, if cubes measuring 200 mm/side having specific strength lower than 50 N/mm2 are to be tested a 2000 kN capacity machine is required. In effect: 200 x 200 x 50 / 1000 = 2000 kN. It must nonetheless be underlined that there is a current tendency to produce concrete with higher performance so it is a good idea to choose a machine which has a higher capacity to that indicated by calculations.

LO 1.2 – Prepare materials, tools, equipment and accessories

Topic: explanation of materials, tools, equipment and accessories used in compression testing

1.2.1. Types of materials

- **Concrete:** is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time.The cement reacts with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses
- **Water**: here we use water in the concrete that mix with cement to establish /increase the bond between the cement, aggregate and the admixture . Water is also responsible for the process of hydration that leads to the hardening of concrete to form different structure.
- **Compression test machine and it's kit**: includes everything you need to check valves and rings, perform carbon buildup inspection and test for late timing on a wide range of vehicles. The kit comes with an extension hose, straight and angled fittings and a rubberized gauge protector

1.2.2. Compression test machine

- **Gauge**: This is the most crucial part of a compression tester because it shows how much compression is in the engine. The tester should deliver accurate readings and should also be large enough to allow you to read easily. Compression gauge is a tool inserted into the spark plug hole on an engine while the flywheel is rotated. This will result in a pressure reading that can be used to judge the condition of a cylinder, piston, and rings.
- **Hose**: are reinforced for involving high pressure to the compression machine.
- **Curved adapter fitting**: is used in pipe systems for compression test machine to connect straight sections of pipe or tube.
- **Straight adapter fitting:** allow for the air to transition smoothly and effectively from one component of compression machine to other component of compression machine.

LO 1.3 – Make concrete sample (specimen)

- Topic: discussion of Preparation of Molds and specimen for concrete used in compression test.

Molds used for preparing samples are in agreement with the standard if the following conditions satisfy:

Molds shall hold their dimensions and shape under all conditions of use.

A suitable sealant, such as heavy grease, shall be used where necessary to prevent leakage through the joints.

Positive means shall be provided to hold base plates firmly to the molds.

Reusable molds shall be lightly coated with oil before use.

1.3.1. Types of sample

- **Concrete cubes**: are used to form specimens for concrete compressive strength testing.
- For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical molds of size 15cm x 15cm x 15cm are commonly used.

- **Bricks:** is a type of block used to build walls, pavements and other elements in masonry construction, brick is used as sample of compression test.

- **Tuff tiles**: a flat or curved piece of fired clay, stone, or concrete used especially for roofs, floors, or walls and often for ornamental work

- **A paver:** is a paving stone, tile, brick or brick-like piece of concrete commonly used as exterior flooring. In a factory, concrete pavers are made by pouring a mixture of concrete and some type of coloring agent into a mold of some shape and allowing setting.

1.3.2. Process for making sample

- Take/Make concrete(Collect concrete ingredients)
- Placing fresh concrete in mould
- Vibrate concrete
- Removal of mould
- Emerge sample
- Follow up of sample emerged

Learning unit 2 –Process testing operations of concrete sample

LO 2.1 – APPY COMPRESSION MACHINE WORKING PLINCIPLES

- Topic : explanation of working principles and procedures of compression machine

Principle of operation

Operation of the machine is by hydraulic transmission of load from the test specimen to a separately housed load indicator.

Load is applied by a hydrostatically lubricated ram. Main cylinder pressure is transmitted to the cylinder of the pendulum dynamometer housed in the control panel. The cylinder dynamometer is also of self-lubricating design. The piston of the dynamometer is constantly rotated to eliminate friction. The load transmitted to the cylinder of the dynamometer is transferred through a lever system to a pendulum. Displacement of the pendulum actuates the rack and pinion mechanism which operates the load indicator pointer and the autographic

recorder. The deflection of the pendulum represents the absolute load applied on the test specimen.

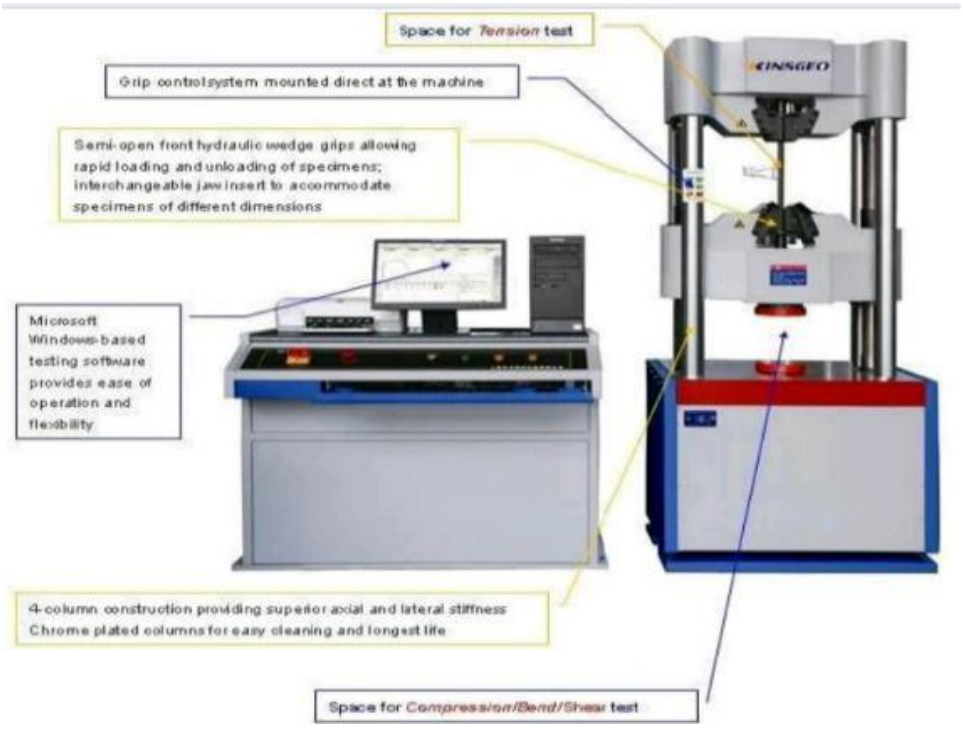
Return movement of pendulum is effectively damped to absorb energy in the event of sudden breakage of specimen.

2.1.1. Compression machine Application (for Check material under compression)

- **Ending**: It better to check if sample is crushed for protecting compression machine
- **Transverse:** It better to checked if material to be compressed is located in the right place of compression machine
- **Brinell hardness:** characterizes the indentation hardness of materials through the scale of penetration of an indenter, loaded on a material test-piece
- **Shear testing:** is designed to apply stress to a test sample so that it experiences a sliding failure along a plane that is parallel to the forces applied.

2.1.2. Compression machine unit

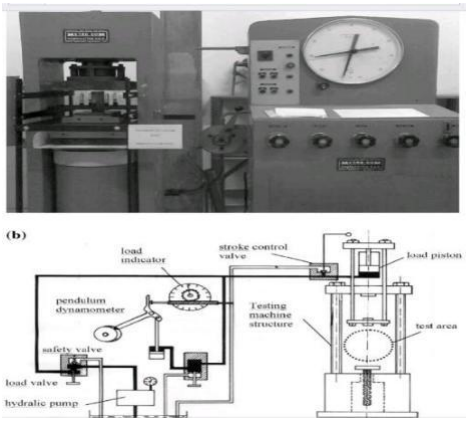
- **Straining unit:** it consists of hydraulic cylinder and a table coupled with the ram of hydraulic cylinder, mounted on a robust base. The cylinder and the ram are individually lapped (cover) to eliminate friction. The cross-head is connected to two screwed columns and is driven by a motor, rapid adjustment of test height.
- **Control panel:** the control panel consists of a power pack complete with drive motor and an oil tank, control valves, a pendulum dynamometer, a load indicator system and an autographic recorder.



- **Power pack:** Power Park generates the maximum pressure of 200kgf/cm2. The hydraulic pump provides continuously no pulsating (act of increase and decrease) oil flow. Hence the load application is very smooth.

- **Hydraulic controls:** hand operated wheels are used to control the flow to and from the hydraulic cylinder. The regulation of the oil is infinitely. Incorporate in the hydraulic system is a regulation valve, which maintains a practically constant rate of table movement.

- **Load measuring & indicating system:** this is system consist of a large dial and a pointer. A dummy pointer is provided to register the maximum load reached during the test. Different measuring ranges can be selected by operating the range selection knob. An overload trip switch is incorporated which automatically, cuts out the pump motor when load range is use is exceeded.



- **Pendulum dynamometer:** this unit permits selection of favourable hydraulic ratios producing relatively small frictional forces. Pressurized oil in the loading cylinder pushes up the measuring piston proportionately and actuates the special dynamometer system. The piston is constantly rotated to eliminate friction. The dynamometer system is provided with an integral damper and ensures high reliability of operation. The load transmitted to dynamometer is transferred through a pendulum to the load indicator.

LO 2.2 – Apply one focal point techniques

Topic: explanation of procedures for concrete cracking in compression testing

2.2.1. Process for concrete crashing of specimen

- **Preparation of concrete specimen**

Remove the specimen from water after specified curing time and wipe out excess water from the surface. Take the dimension of the specimen to the nearest 0.2m Clean the bearing surface of the testing machine

- **Placing of specimen into compression machine**

Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast Align the specimen centrally on the base plate of the machine.

Start machine or turn on the compression machine

Lowering the piston against the top of concrete specimen by pushing the lever. Don't apply load just now. Just place the piston on top of concrete specimen so that it's touching on it.

- **Apply load based on designed load**

Now the piston is on top of specimen.it is time to apply load. Pull the lever into holding position start the compression test by pressing the zero buttons on the display board.

- **Increase pressure or load by adjusting compression valve**

Increasing the pressure: by turning pressure increasing valve counter clockwise, adjust the pressure on piston so that it matches concrete compression strength value. Apply the load gradually without shock

- **Verify if test is complete (crushed).**

Test is completed: observe the concrete specimen when it begins to break stop applying load

Record the maximum or ultimate load on paper displaying on machine's display screen.

- **Clean the machine:**

When the piston is back to its position, clean the creaked concrete from the machine.

Note: Minimum three specimens should be tested at each selected age. If strength of any specimen varies by more than 15 % of average strength, results of such specimen should be rejected. Average of three specimens gives the crushing strength of concrete. The strength requirements of concrete.

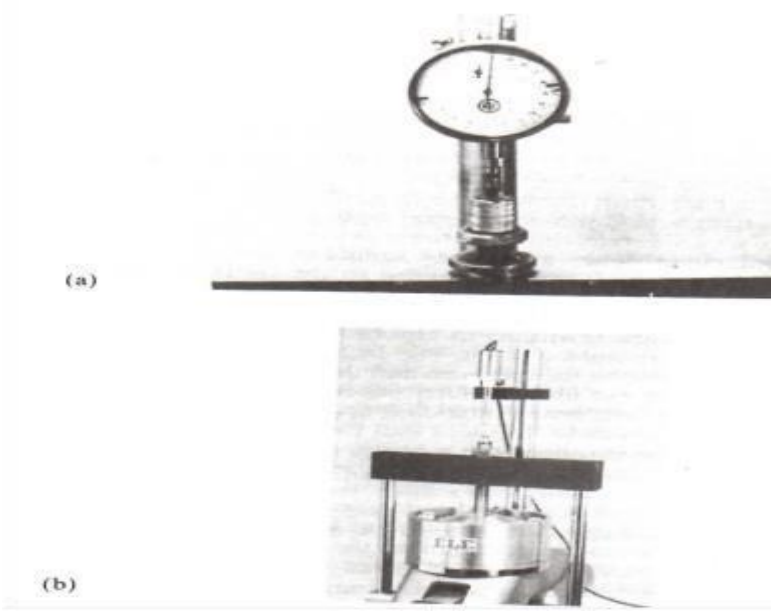
LO 2.3 -Read test results

- Topic : explanation of gauge reading result for compression machine

2.3.1. Process of Gauge Readings:

- On a normal cylinder, the gauge needle should travel up the scale on each compression stroke until it reaches peak value.
- If the gauge needle does not travel up the scale or if it remains at the same value for several strokes and then starts to climb, the problem could be a valve sticking
- If the compression reading is considerably higher than the vehicle manufacture's specification, the problem may be carbon build-up in the cylinder
- If a reading on two adjacent cylinders is 20psi(or more) lower than the other cylinders, the problem may be carbon build-up in the cylinder

- If the readings are low, or vary widely between cylinders, pour a teaspoon of SAE 30 oil into each cylinder and retest them



Compressive Strength Formula

Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area

Compressive Strength of Concrete at Various Ages

The strength of concrete increases with age. Table shows the strength of concrete at different ages in comparison with the strength at 28 days after casting.

Table 1: Descriptive classification of fracture character in stability tests

Fracture character	Code	Fracture characteristics
Progres-sive Com-pression	PC	Fracture usually crosses column with one loading step, followed by gradual compression of the layer with subsequent loading steps
Resistant Planar	RP	Planar or mostly planar fracture that requires more than one loading step to cross column and/or block does not slide easily* on weak layer.
Sudden Planar	SP	Planar fracture suddenly crosses column with one loading step and the block slides easily* on weak layer.
Sudden Collapse	SC	Fracture suddenly crosses column with one loading step and causes noticeable slope normal displacement.
Non-planar Break	B	Irregular fracture surface.

Learning unit 3 – Interprets and reports the results

LO 3.1 – Interpret fracture classifications

- Topic : discussion of fracture classification in compression testing

3.1.1. Types of classifications of fracture

There two classification sudden and resistance

A.Sudden classification

- **Sudden planar:** Planar fracture suddenly crosses column with one loading step and the block slides easily on the weak layer.
- **Sudden collapse:** Fracture suddenly crosses column with one loading step and causes noticeable slope normal displacement.

Resistant classification

- **Progressive compression:** Fracture usually crosses column with one loading step, followed by gradual compression of the layer with subsequent loading step
- **Resistant planar:** Planar or mostly planar fracture that requires more than one loading step to cross column and/ or block does not slide easily* on weak layer
- **Break:** Irregular fracture surface

LO 3.2 -Identify elements for compression test report

- Topic: discussing the elements used for compression test report.

3.2.1. Elements required in the report of each specimen:

- **Identification Mark:** this is the mark that given to the specimen in order to differentiate them.
- **Date of test:** the date of test must be reported
- **Age of specimen:** the date of specimen must be reported because it also help while we are analysing the result.
- **Curing conditions, including date of manufacture of specimen in the field**
- **Weight of specimen.**
- **Dimension of specimen:** the most common used is (15*15*15)cm or diameter of15 cm to 30 cm of height
- **Cross sectional area.**
- **Maximum load.**
- **Compressive strength.**
- **Appearance of fractured** faces of concrete and type of fracture, if these are unusual Fracture surface

3.2.2. The conditions affect the quality of the concrete in both the structure and in the specimens.

- **Improper moulding of the specimens** may result in honeycombed sections in specimens. Honeycombing indicates improper moulding methods, segregation of the coarse aggregate or a batching error resulting in excessively high rock content of the mix.

- **Rough handling of cylinders**, particularly during early ages, will cause fractures or planes of weakness in the cylinders. Disturbance of any nature during the setting period may reduce the concrete strength.

- **A decrease in the cement content of the mix** by either withholding part of the cement per batch or by increasing the quantity of aggregates per batch reduces the concrete strength. During the proportioning operations, assure that the proper quantities are measured out. Where sacked cement is furnished, assure the full content of each sack is placed in the mixer.

- **The use of dirty or contaminated aggregates** results in a lower bond strength between the cement paste and the aggregates, thus producing a poorer quality cement paste, thereby reducing concrete strength.

- **Increasing the water content of the mix for easier workability without increasing the cement** content to compensate for the additional water results in a weakened cement paste. Use sufficient water to give the desired consistency; additional water will shorten the life of the concrete structure. Water above the amount in the batch design results in a weaker cement paste along with a decrease in strength.

- **Decreasing mix time**, either intentional or otherwise, may leave portions of both sand and gravel that are uncoated with cement paste. Worn mixing blades can also result in reduced mixing action.

LO 3.3 – Describe the result.

- Topic : description of specimen result in compression testing of concrete

3.3.1. Types of decisions

I. **Rejected materials:** The result is rejected means the concrete specimen you tested does not have desired strength based on the maximum load applied on given period of time.

II. **Acceptable materials:** The result is accepted means the concrete specimen you tested has desired strength based on the maximum load applied on given period of time.

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