Placement and Compaction

- a Pre-mix Suppliers Perspective -

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.

Introduction

Areas covered:

- 1. Mix design and material properties;

- 2. Batch Plant;

- 3. On site; and

- 4. Defects.

Mix Design Considerations

Two KEY aspects of the Mix Design relate to placement and compaction

1. Avoid segregation

Mix stability

- defined as the concrete's resistance to bleeding and segregation.

2. Aid compaction

Mix compactability

- defined as the ease with which fresh concrete is consolidated and entrapped air is removed from the concrete.

Mix mobility

- defined as the flowability of the concrete and described in terms of viscosity, cohesion and internal resistance to shear.

Mix Stability

with relation to Bleeding

- Bleeding is the name given to the action of water rising to the top of concrete shortly after compaction. Mix design factors which affect bleeding are:
  - Consistency or slump (particularly high slumps 140mm +)
  - Volume of fines in the mix



- Bleeding is generally reduced by:
  - A reduction in the water content of the mix
  - An increase in the ultra fines content of the mix (this may increase shrinkage)
  - The use of specialist admixtures (ie Air Entrainers, fibres)

Mix Stability

with relation to Segregation

- Segregation is defined as the separation of the components of fresh concrete such that they are no longer uniformly mixed. Mix design factors which may affect segregation are:
  - Cementitious content
  - Consistency or slump (wet mixes are generally more prone to segregation)
  - Grading of aggregates (particularly fine aggregates)

- Segregation is generally reduced by:
  - An increase in cement (increase in cohesiveness and resistance to segregation)
  - A reduction in the water content of the mix
  - An increase in the ultra fines content of the mix

Mix Compactability

the effect of consolidation

- Consolidation is the name given to the action of packing the constituent particles as close together as possible. Mix design factors which affect consolidation are:
  - Aggregate grading and particle shape
  - Cement content & paste volume; and
  - Consistency or slump (consolidation improves with increases in slump)

- Consolidation is generally improved by:
  - Increasing lubrication of constituent particles in the mix such as:
    - increasing cement fines (consider secondary cementitious products)
    - increasing water or using admixtures (ie Super plasticisers)
    - using continuously graded aggregates to minimise void space

Mix Compactability

with relation to removal of entrapped air

- Removal of entrapped air is the second stage of compaction and is necessary to achieve the greatest possible density of concrete.
- Mix design factors which affect entrapped air are:
  - Admixture useage; and
  - Cement content and type

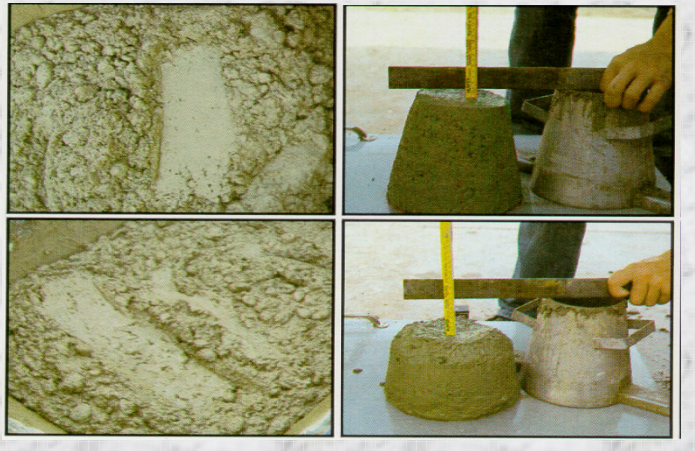
IMPORTANT
Concrete generally needs the entrainment of air to improve mix stability and mobility whilst in the plastic state. Entrapped air can generally be easily removed with appropriate compaction techniques.

- Entrapped air is generally reduced by:
  - Not using air entraining admixtures, but suffering a loss in workability
  - Increasing the cementitious content of the mix
  - Using supplementary cementitious materials such as flyash, slag or silica fume if they are significantly finer than cement

Mix Mobility

the effect on the flow of concrete

- Flowability of concrete is defined in terms of its viscosity, cohesion and internal resistance to shear. Mix design factors which affect these parameters are:
  - Admixture useage
  - Slump and water content
  - Cement content and type
  - Aggregate grading and particle shape



- Mix mobility is generally improved by:
  - Increasing admixture useage (superplasticisers, air entrainer, water reducers)
  - Increasing the water and cementitious content of the mix
  - Increase mix fines (sands, cementitious materials - flyash, slag, silica fume)
  - Avoid poorly shaped particles

Lets have a closer look at aggregate shape

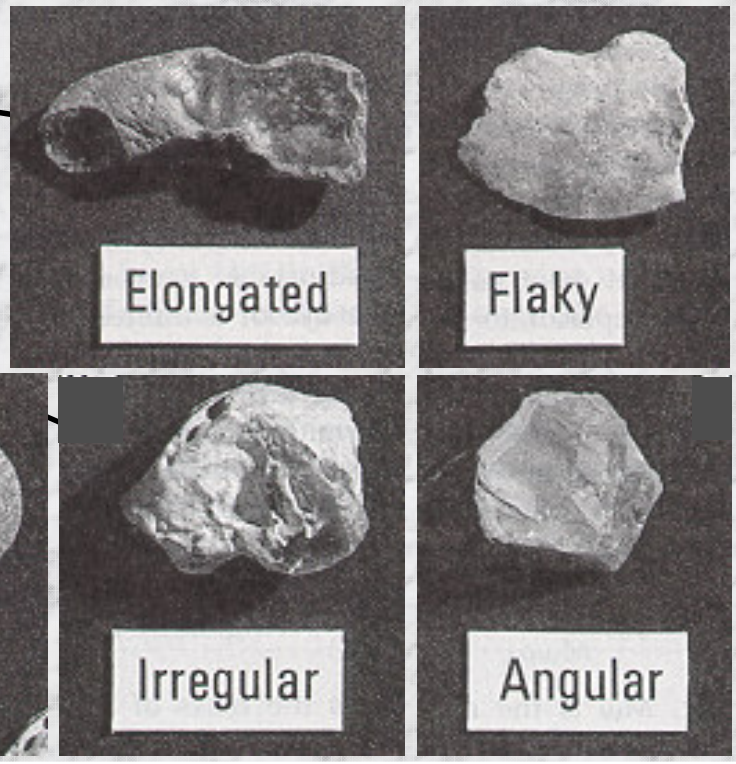
Aggregate Shape

the effect on mobility

Shape of aggregate has an important influence upon the workability of fresh concrete.

AS2758.1 provides guidance on the classification of shape. They are as follows:

- **FLAKY**
- **ELONGATED**
- **ANGULAR**
- **IRREGULAR**
- **ROUND**



Round produces the best workability

Two key reasons:

1. Ball bearing effect
2. Smallest surface area. More paste available for flowability of the mix

Batch Plant

need to ensure compliance with the mix design

- Batching accuracy
  - Why batch accurately?
  - What are the tolerances?
  - Computers & records
  - Weighing Equipment;
  - Liquid Dispensing; Equipment; and
  - Mixing Equipment
  - Slump control

Why Batch Accurately?

- Accurate batching is a prime concern for every concrete plant to ensure the closest possible compliance with the given mix design.
- AS1379 recognises that tolerance are a practical necessity and has set requirements for all concrete ingredients.
- Errors in batching can alter the concrete's expected properties. The following are examples of effects on placement and compaction

- Under batched cement may result in loss of cohesiveness and segregation at high slump
- Over batched coarse aggregate will reduce workability and pumpability
- Under or over batched fine aggregate will alter shrinkage, flowability and ease of compaction. Underbatched fines may increase bleed.
- Over or under dosed admixture will alter plastic duration, bleed, and mix mobility
- Like admixtures, water content will alter plastic duration, bleed, mix mobility and has an enormous affect on Strength and Durability of the concrete.

What are acceptable tolerances?

Table 5 of AS1379

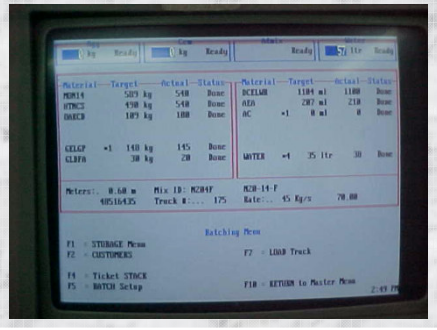
	Tolerance			
	Weight batching for batch size Q			Volume batching
	$Q < 2\ m^3$	$2m^3 <= Q <= 4m^3$	$Q > 4m^3$	
Each cementitious ingredient	-5 + 30 kg	-10 + 30 kg	-20 + 40 kg	±1%
Total cementitious materials	-5 + 30 kg	-10 + 30 kg	- 20 + 40 kg	±1%
Fine aggregate	-75 +50 kg	±75 kg	±100 kg	±2%
Coarse aggregate	-75 +50 kg	±75 kg	±100 kg	±2%
Total aggregate	-75 +50 kg	±75 kg	±100 kg	±2%
Chemical admixtures	±5% *	±5% *	±5% *	±5% *

* or 20 mL, whichever is greater

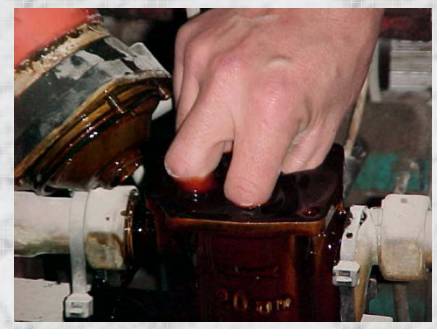
How tolerances are met

- Computers control batching and help to ensure tolerances are met;
- Regular maintenance and calibration of equipment reduces malfunctions; and
- Calibration records provide evidence of the work done.

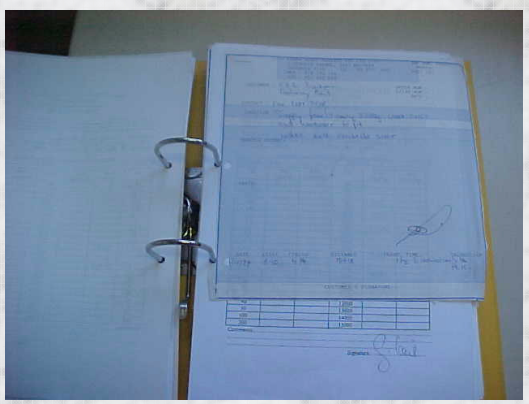
Computer systems



Equipment maintenance



Calibration Records



Batching Records

verify accuracy and provide traceability

Records containing the source, type and target quantity of each ingredient used in the production of each batch are maintained for 12 months

Records are also kept of the date and time of any plant malfunctions

Example of batch record

Docket No	Truck No	Mix Code	Slump	Load size
48929442	758	N254F	70	3.60

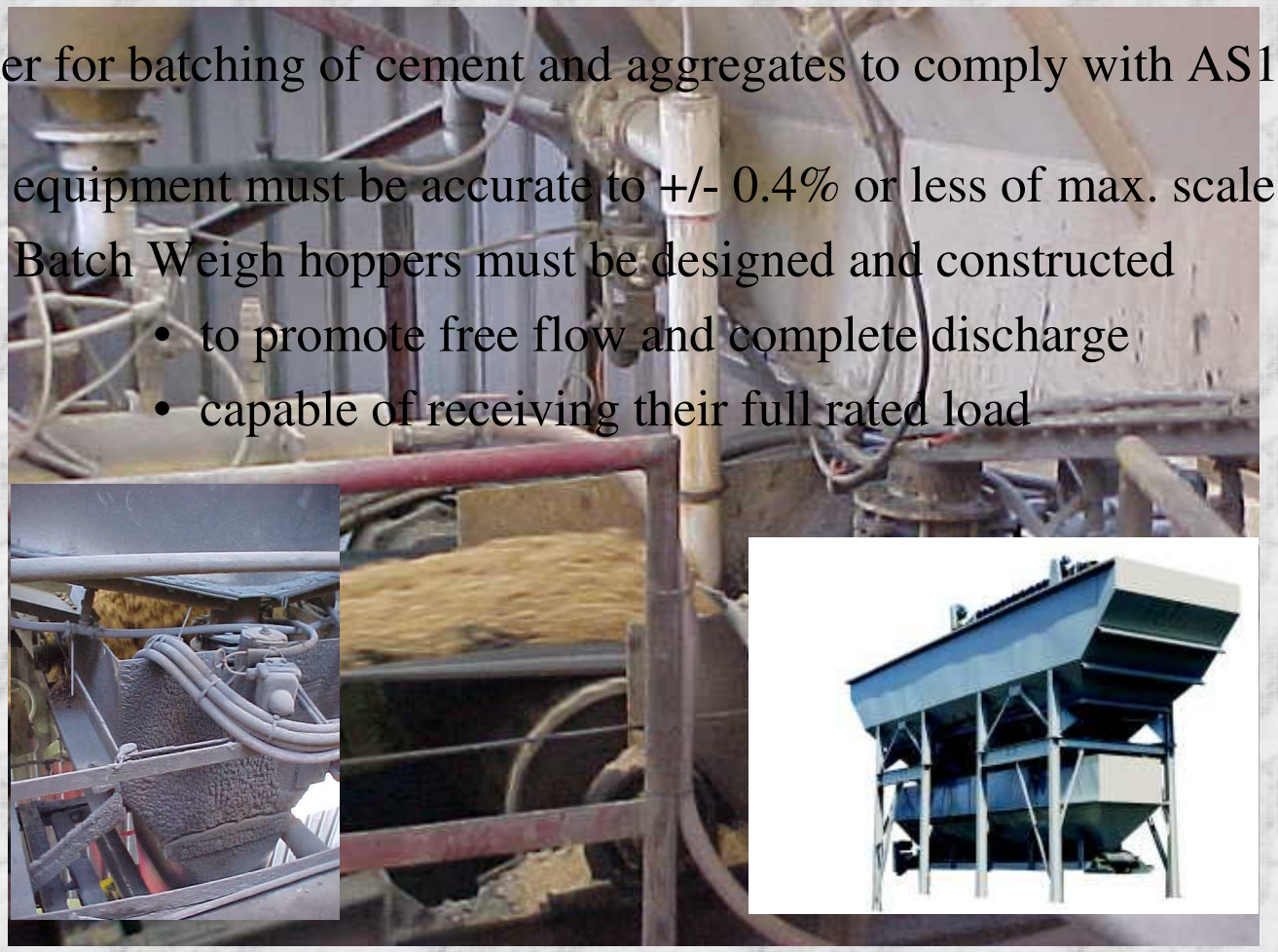
Material Code	Target	Actual	Difference	% Difference
OAK14	003700	003700	0	0.00
HTNCS	002486	002500	14	0.56
LYNCS	000960	000960	0	0
GOLGP	000748	000750	2	0.27
GLDFA	000183	000180	-3	-1.64
DCELWR	006552	006450	-102	-1.56
AEA	001404	001420	16	1.14
WATER	000180	000182	2	1.11

Weighing Equipment

ensure compliance with the mix design

In order for batching of cement and aggregates to comply with AS1379

- equipment must be accurate to +/- 0.4% or less of max. scale value
- Batch Weigh hoppers must be designed and constructed
  - to promote free flow and complete discharge
  - capable of receiving their full rated load



Liquid Dispensing Equipment

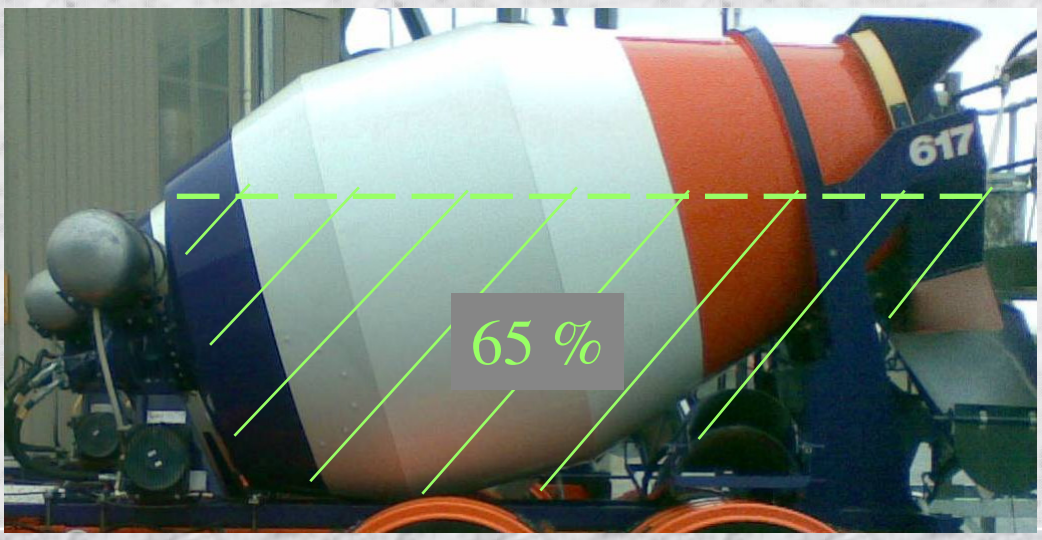
In order for batching of water and admixtures to comply with AS1379

- equipment must be accurate to +/- 2.0% or less of the value shown on the indicating device for water
- equipment must be accurate to +/- 5.0% or less of the value shown on the indicating device for other liquids
- the frequency for calibration of dispensing equipment cannot exceed 6 monthly.

Batch Mixing Equipment

- Batch Mixers are designed to:
  - uniformly distribute ingredients throughout the volume of mixed concrete with the minimum mixing time or number of revolutions necessary.
  - have variable speed for mixing, discharging and agitating
  - have a rated mixing capacity not more than 65% of the gross internal volume of the mixing chamber unless proven otherwise

Common truck mounted mixing barrel



Mixer Design/Manufacture

- Correctly designed and manufactured mixers will have identification plates detailing:
  - gross internal volume of the mixer (m3)
  - rated mixing capacity (m3)
  - recommended minimum mixing time or revolutions required to achieve uniformity

Typical Identification Plate

Slump Control

- A sufficiently experienced operator will assess the consistency of a batch and estimate any further addition of water needed to produce the specified slump
- Water is added via a hose fitted with a measuring device
- Slump tests are conducted on site to confirm the consistency of concrete

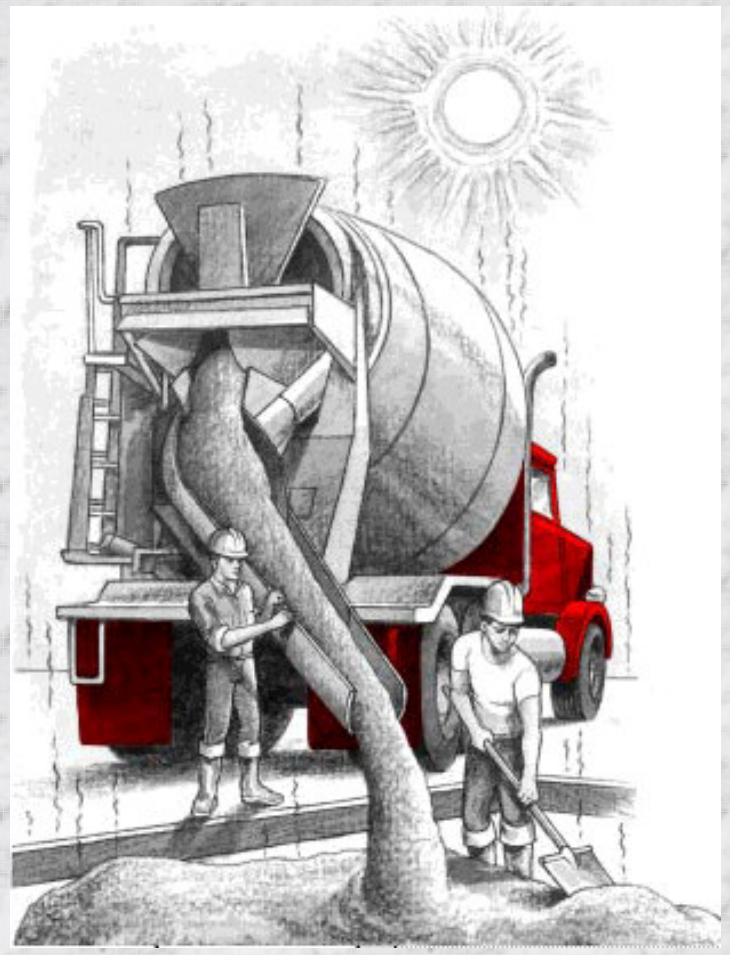
Slump Stand at the Concrete Plant


Slump test

On site

Placement and Compaction of concrete on site should consider the following:

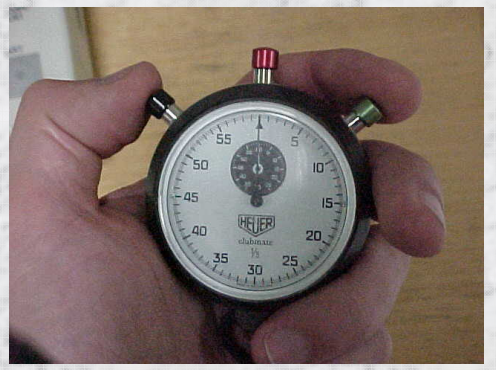
- Temperature and Duration
- Placement method and compactive effort



Temperature and Duration

- It is important to control delivery of plastic concrete so as to:
  - prevent segregation; and
  - avoid premature stiffening

- Be aware that
  - Elevated concrete temperature can result in
    - premature stiffening; and
    - rapid loss of workability



- And
  - Delays in completion of discharge can result in
    - loss of workability
    - cold joints (discussed later)

Addition of water to restore the consistency will generally reduce the quality of the finished product

Placement and Compaction

- How to avoid segregation on site
  - avoid very wet or very dry concrete mixes (these are most susceptible)
  - avoid uncontrolled drops (use a drop chute or a pump hose)
  - always deposit concrete into the face of that already placed
  - always commence placing from the lowest point in a pour
- How to aid compaction on site
  - use a correctly tailored mix design for the job (pump, tremmie, etc)
  - place concrete in layers which are a suitable depth for the compaction equipment
  - use the correct compaction equipment for the job; and
  - ensure the compaction equipment is used correctly

Concrete Defects

due to poor placement and compaction

Defects can be caused by many factors including:

- Design & Construction
  - improper placement due to design and detailing of structural member
  - improper design/selection of concrete mix to suit placement conditions
  - improper placement practices; and
  - improper vibration and consolidation practices.
- Equipment
  - improper selection of equipment for application; and
  - equipment failure or interuption of service .
- Materials
  - material batching errors
  - improper use of admixtures; and
  - Improper use and selection of release agents.
- Environment
  - exrtreme weather conditions.

Lets take a closer look at some common defects

Concrete Defects

due to poor placement and compaction

Honeycombing

Stony surface with air voids. Appears lacking in fines

Caused by:

congested reinforcement and difficult construction conditions
insufficient paste in the concrete mix (or over batch in coarse aggregate)
improper placing techniques (segregation and/or lack of vibration); and
premature stiffening of concrete (accelerating admixtures and/or high temperatures)

Concrete Defects

due to poor placement and compaction

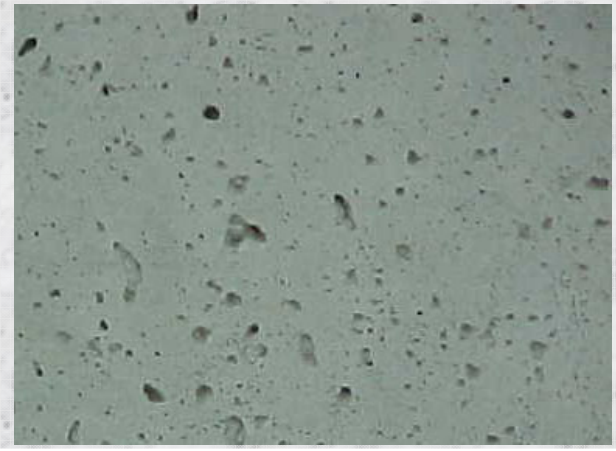
Bugholes

Appear as voids in the surface of off-form finished concrete. Vary in size upto 25mm.

Caused by:

air bubbles trapped between the concrete mass and the form, especially in sticky or stiff concrete mixtures of low workability which may have an excessive sand and/or entrapped air content; and

lack of complete vibration or proper insertion of the vibrator head may increase bughole formation.



Concrete Defects

due to poor placement and compaction

Layer lines

Appear as dark lines on formed surfaces which indicate the boundary between concrete placements.

Caused by:

stiffening or insufficient consolidation of the lower level due to lack of penetration of the vibrator into the lower level

Concrete Defects

due to poor placement and compaction

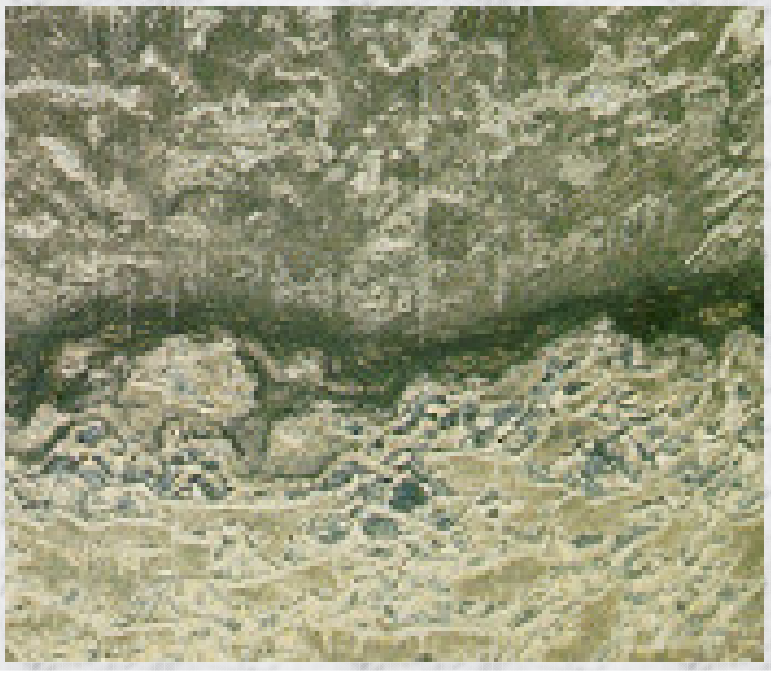
Cold Joints

Appear as a discontinuity between concrete placements. Similar to Layer lines

Caused by:

stiffening of the of the concrete before further concrete can be placed against it creating a discontinuity which generally results in a weak plane within the finished structure; and

Cold joints can be avoided by contingency planning, back up equipment, and working to vibrate into lower lifts (if possible)



Concrete Defects

due to poor placement and compaction

Settlement or Subsidence Cracking

Cracks that occur due to settlement whilst the concrete is still plastic.

Caused by:

These cracks occur as a result of settlement of concrete, after or near initial set, that is restrained by a local obstruction, or by a dramtic change in section depth.

They typically occur over reinforcing bars with shallow cover.

However, can also occur in columns where the upper concrete bridges between the forms while the lower concrete settles.

End of Presentation

- Thankyou for your attention