RCC Mixing-
What the numbers don't tell you.

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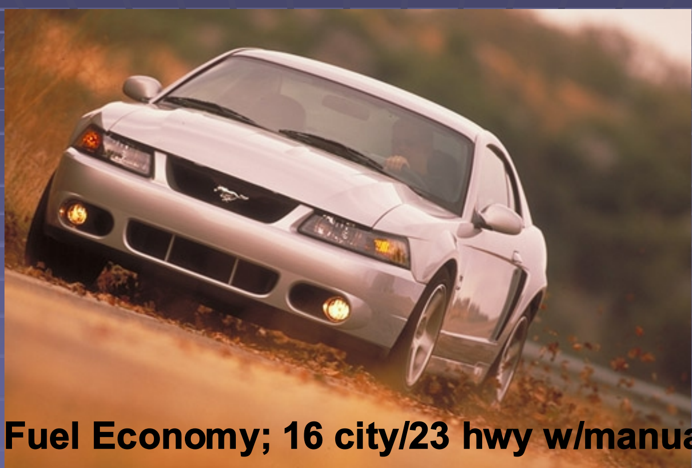
What the numbers don't tell you!



What the numbers don't tell you!

Fuel Economy;
3.7 Track w/manual

Mixing RCC... A Belief System.

- Like major Religions, the Origin of the Universe, High or Low Cementitious RCC, GERCC or GVRCC many strongly held opinions are not necessarily based supportable facts.
- Rather they are based on opinions, limited prior experience, lack of understanding of the known facts, of just plain intellectual laziness.
- Views held are right beyond doubt and debate to many of those who hold them strongly.
- So it is with mixing RCC.
- Two traditions are applied in mixing RCC.
- Continuous Metering and Mixing, or Batch Proportioning and Mixing.
- Are either wrong?
- Can both be right?
- It starts as a point of reference.
- Is a 35 degree day Hot or Cold?

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Continuous Mixing Plant

400 m^3/hr x 2 = 800 m^3/hr available capacity.

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Batch Mixing Plant

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Topic Overview.

- Process..
- Begin with a group of disparate ingredients.
- Carefully measure and mix them.
- Produce a tightly defined mixed concrete material referred to as RCC.

- Issues..
- The ingredients themselves, their relationship one with another, process, definition, measurement, accuracy, and quality.
- The continuum of materials which are bound by cementitious materials, where RCC for dams fits into that continuum.
- How different "traditions" have developed in sub sections of this wide spread materials range.

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Topic Overview.

- Mixing RCC..
- "Batching" and the "Continuous" or "Through Mixing" processes.
- Limitations and compromises inherent to each method.

- Proportioning.. Batching.. Metering.
- A definition.
- Proportioning devices and their accuracy.

- Mixers..
- Batch and Continuous Mixers.
- Mixing Time.
- Mixer Tests.

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Topic Overview.

- The "Specification"..
- It attempts to describe what is "required" and to exclude what is "definitely not required".
- Specification of Accuracy. How is it ever measured?
- Outcome or Prescription?
- Does anyone comply? Does anyone know?

- Tricks that Contractors play..

- How does it affect me?
- Specification writers.
- Contractors.
- Site Engineers & Inspectors.

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What makes up unit volume of RCC?

- Fines, sand or crushed aggregate
- which fills the void between
- Small stones
- which fills the void between
- Large Stones
- which is all bound together and filled by
- Cement and Pozzolan (flyash)
- which reacts with
- Water
- and is modified by
- Additives
- to form a densely graded concrete, RCC.

In the first instance;
These are volumetric relationships.

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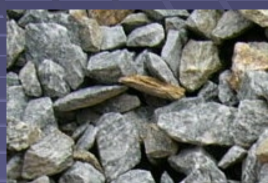
Defining a Recipe.

- **Volume…**
  - These volumetric relationships are;
  - Established in the Lab with samples of material of limited diversity.
  - May or may not accurately represent what is actually to be used at any future moment.
- **Weight…**
  - Weight is used as a convenient measure to;
  - Define the volume of each individual particle needed to make unit volume.
  - Meet the strength, workability and compacted density targets.

Measuring Aggregate Size

- Sieve Size..
  - Used to describe material which will when shaken, pass through a defined square opening.



- 3 inch aggregate

- It says nothing about..
  - Shape
  - Flakiness
  - Voids ratio in loose material
  - Stone density

"Numbers Problem #1."

- Recipe definition by sieve size and weight (kg / m^3)..
  - Does not tell you that the recipe volume relationship holds true.
  - Does not assure that a 1 m^3 batch with precise recipe weight quantities will achieve 1 m^3 of RCC.
- You order concrete by volume and it is manufactured by weight.
- Do you get the exact volume ordered? Usually less if the supplier controls it.
- Do the batch records show that you got what you ordered?
- By weight "yes".
- By volume, well "no" because it is not measured at the manufacture stage.

"Numbers Problem #2." Inverse Calibration..

- By using weight as the defining measure of what is primarily a volumetric relationship;
- Step 1..volume to weight conversion.
- Step 2..weight to volume conversion.
- Do we get what we started with??
- Weight of what? Shape, grading and density.

By using weight as the defining measure of what is primarily a volumetric relationship, we are making a volume to weight conversion and then reversing it to a weight to volume conversion. Do we get what we started with??

- Путем использование веса как определяющ измерением будет главным образом объемное отношение, мы делаем том для утяжеления преобразования и после этого обращаем его к весу к преобразованию тома. Мы получаем мы начали с??
- By use of weight as определяющ measurement will be mainly the volumetric attitude, we do volume for weighting transformation and after that we turn it to weight to transformation of volume. We receive we have begun with??
- Not exactly!
- 由使用重量作为定义什么的措施是主要一个容量关系，我们做容量衡量转换和然后扭转它对重量对容量转换。我们得到什么我们开始了与??
- Defines any by the operating weight achievement the measure is the main capacity relations, we make the capacity weight transformation and then reverse it to the weight to the capacity transformation. What did we obtain us to start and? ?
- Chinese is even worse!

Mixing RCC.
Step 1; Proportioning the Ingredients.

- Each of the ingredients must be present in the correct proportions each to the other.
- This process is variously called;
- Batching
- Metering
- Proportioning.
- We will use the term "proportioning" to generalize.

Throughput m3/hr 400 Material Spec	Mix Proportion (Recipe) kg / m3
Flyash	100
Cement	100
Total Cementitious	200
Sq (quarry sand)	594
Sm (mining sand)	255
63~40 mm¨	226
20~5 mm	543
40~20 mm	453
Total Aggregates	2271
Total Dry Weight	2471
Water A	60
Water B	80
Total Water	140
Total Ingredients	2611

Proportioning..

The Proportions can be expressed in many ways.

Throughput m3/hr 300 Material Spec	Mix Proportion (Recipe) kg / m3	Mix Proportion % of Dry Weight	Input Tonnes per Hour	Loose Density tonnes / m3	Loose Volume m3/hr	Req'd Feeder Speed from sensor Hz
Flyash	100	4.0%	30.0	1.20	25.00	4.82
Cement	100	4.0%	30.0	1.13	26.55	5.12
Total Cementitious	200	8.1%	60.0		60.0	
Sq (quarry sand)	594	24.0%	178.2	1.38	129.13	10.00
Sm (mining sand)	255	10.3%	76.5	1.26	60.71	4.70
63~40 mm¨	226	9.1%	67.8	0.95	71.37	5.53
20~5 mm	543	22.0%	162.9	1.22	133.52	10.34
40~20 mm	453	18.3%	135.9	0.85	159.88	12.38
Total Aggregates	2271	91.9%	681.3		681.3	
Total Dry Weight	2471	100.0%	741.3		741.3	
Water A	60	2.4%	18.00	1.00	18.00	266.22
Water B	80	3.2%	24.00	1.00	24.00	351.70
Total Water	140	5.7%	42.00			
Total Ingredients	2611	105.7%				

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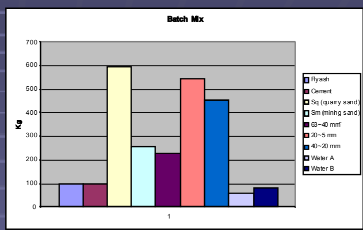
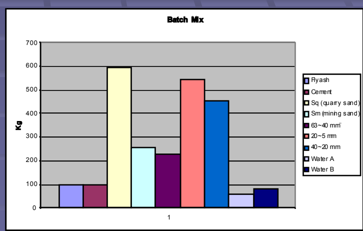
Making RCC to a Recipe.. The Batch Approach.

- 1. Determine the required quantity of each ingredient according to the recipe and the batch size.
- 2. Individually weigh out the required quantity of each ingredient.
- 3. Dump these materials into the mixer in their segregated state.
- 4. Wait until the mixer can make the whole homogeneous.
- 5. Discharge the batch.





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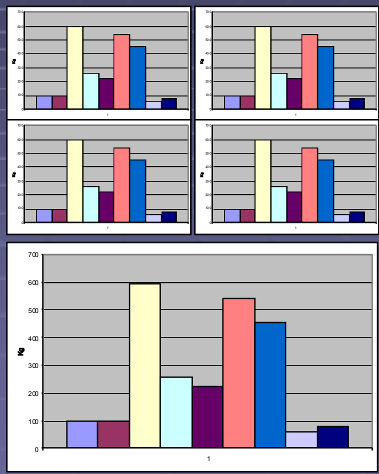
Making RCC to a Recipe. The Batch Approach.

- For more, repeat steps 1 to 5 over and over.
- To go faster, make bigger batches, or have more weighing and mixing systems.
- Every batch is a
- NEW PROJECT.



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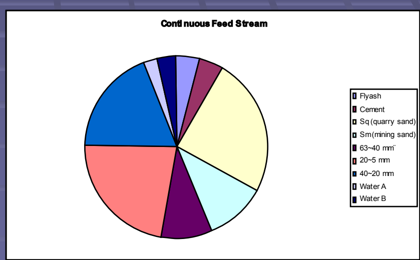
Making RCC to a Recipe.. The Continuous Mixing Approach.

- Major emphasis in this process is on PROPORTIONING.
- At any instant, all of the ingredients in the feed stream are in the correct proportion one to another.
- The mixer takes that stream and completes the job of macro and micro mixing to achieve homogeneity.



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Making RCC to a Recipe..
The Continuous Mixing Approach.

- 1. Set up the recipe and the required output rate.
- 2. Start the system.
- 3. Make a coffee or have some fun.
- 4. When the job is done, stop the system.

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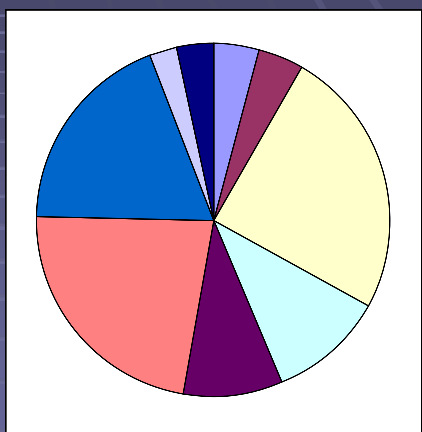
Making RCC to a Recipe..
The Continuous Mixing Approach.

- For large quantities, run as long as is needed.
- To go faster, speed it up.



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"Numbers Problem #3."...

Moisture Content.. Do I have sand / fines or water?

- The Included Water Problem… Batch Approach.
- Fines can carry a lot of water..0% to 20%.
- Commonly range 3%-6% of dry weight.

Throughput m3/hr 300 Material Spec	Mix Proportion (Recipe) kg / m3	Water Included with Agg % of Dry Weight	Water Included with Agg kg/m#	Target Batch Weight kg / m3
Flyash	100			100
Cement	100			100
Total Cementitious	200			200
Sq (quarry sand)	594	3.0%	17.8	**612**
Sm (mining sand)	255	6.0%	15.3	**270**
63~40 mm¨	226	1.0%	2.3	**228**
20~5 mm	543	1.5%	8.1	**551**
40~20 mm	453	1.3%	5.9	**459**
Total Aggregates	2271	Total Ind Water	49.4	2320
Total Dry Weight	2471	Total Wet Weight		2520
Total Water	140		Added Water	**90.6**
Total Ingredients	2611			2611

"Numbers Problem #3."...

Moisture Content.. Do I have sand / fines or water?

- The Included Water Problem.. The Continuous Approach.

Throughput m3/hr 300 Material Spec	Mix Proportion (Recipe) kg / m3	Water Included with Agg % of Dry Weight	Water Included with Agg kg/m3	Input Tonnes per Hour (dry)	Loose Density (dry) tonnes / m3	Loose Volume m3/hr	Req'd Feeder Speed from sensor Hz
Flyash	100			30.0	1.20	25.00	4.82
Cement	100			30.0	1.13	26.55	5.12
Total Cementitious	200			60.0		60.0	
Sq (quarry sand)	594	3.0%	17.8	178.2	1.38	129.13	10.00
Sm (mining sand)	255	6.0%	15.3	76.5	1.26	60.71	4.70
63~40 mm¨	226	1.0%	2.3	67.8	0.95	71.37	5.53
20~5 mm	543	1.5%	8.1	162.9	1.22	133.52	10.34
40~20 mm	453	1.3%	5.9	135.9	0.85	159.88	12.38
Total Aggregates	2271	Total Ind Water	49.4	681.3		681.3	
Total Dry Weight	2471	Total Wet Weight		741.3		741.3	
Water A	60	Added Water	60	18.0	1.00	18.00	266.22
Water B	80	Added Water	**30.6**	**9.2**	1.00	**9.18**	**134.46**
Total Water	140		140	27.2			
Total Ingredients	2611						

"Numbers Problem #3."...

Moisture Content.. Do I have sand / fines or water?

- Batch Approach.
- Batching system takes no account of the volume of batched fines.
- If included water adjustment is wrong;
- The dry weight or number of grains of sand is also wrong.
- The added water amount is also wrong.

Throughput m3/hr 300 Material Spec	Mix Proportion (Recipe) kg / m3	Water Included with Agg % of Dry Weight	Water Included with Agg kg/m#	Target Batch Weight kg / m3	Actual Incl Water with Agg % of DryWeight	Dry Weight Error kg
Flyash	100			100		
Cement	100			100		
Total Cementitious	200			200		
Sq (quarry sand)	594	3.0%	17.8	612	4.0%	-5.9
Sm (mining sand)	255	6.0%	15.3	270	7.0%	-2.6
63~40 mm¨	226	1.0%	2.3	228	1.0%	0
20~5 mm	543	1.5%	8.1	551	1.5%	0.0
40~20 mm	453	1.3%	5.9	459	1.3%	0.0
Total Aggregates	2271	Total Ind Water	49.4	2320		
Total Dry Weight	2471	Total Wet Weight		2520		-8.5
Total Water	140		Added Water	90.6		8.5
Total Ingredients	2611			2611		

"Numbers Problem #3."...

Moisture Content.. Do I have sand / fines or water?

- Batch Approach.
- Commonly, batching systems add the final amount of water according to the mixer load (amps in electric drives).
- This adjusts the slump or workability of the mix.
- It takes no account of a deficit or surplus of fines or sand.
- There is no way of knowing whether the correct amount of fines or sand is there or not.
- Significant and variable water addition corrections during mixing indicate variable fines addition.
- Mixer load varies with batch size. Correction only works, more or less for multiple batches of the same size.
- The "numbers do not tell you exactly how much fines is in the mix."

"Numbers Problem #3."...

Moisture Content.. Do I have sand / fines or water?

- Continuous Mixing Approach.
- The feed rate of the aggregates and fines / sand is not normally adjusted for changes to included water.
- The volume of fine material is unaltered.
- In a well designed system, the fines are re-loosened in the metering zone.
- Within the typical range of moisture contents, bulking has little effect.
- Only the added water is adjusted to reflect measured included water.
- The effect of included water changes is smoothed in this process.
- The "numbers do not tell you exactly how much fines is in the mix", but they will be closer.

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"Numbers Problem #4."...

Weighers.. % of full scale deflection. True accuracy at working load?

- When "Weight" is the primary measure, then the system is wholly dependent on weighing equipment.
- Modern weighing devices are generally very accurate, but an understanding of "Accuracy" will qualify just how accurate.

- RCC Specifications typically call for weighers accurate to 1%
- 1% of what???

- An electronic weigher has three parts.
- 1. The weigh vessel
- 2. The load cell or cells which support it.
- 3. The electronics which interpret the data.

- Each adds its own compromise to the available data.

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"Numbers Problem #4."...

Weighers.. % of full scale deflection. True accuracy at working load?

- Load Cells..
- A load cell is an accurately shaped metal block which when subjected to load deflects.
- A resistance grid known as a Wheatstone Bridge is glued to it.
- The strain resulting from the load alters the resistance of the bridge.
- Load Cell Sensitivity is quoted in miliVolts/Volt.
- Note that the load cell sensitivity has a wide tolerance.
- No two similar cells are the same. Each has to be individually calibrated.
- Note that Error is quoted as % of Full Scale Deflection.

SPECIFICATIONS

Rated Capacities	25,50,75,100,150,200,250,500,750,1K,2K,2.5K,3K,5K,10K,15K & 20KLb
Full Scale Output - 25 –3KLb	3.0mV/V +25%/-10%
- 5K – 20KLb.	3.0mV/V +/-0.25%
Combined Error	≤0.03% FS
Non-Linearity	≤0.03% FS
Hysteresis	≤0.02% FS
Creep Error	≤0.03% FS in 20 minutes
Temperature Effect on Zero	≤0.0015% FS/°F
Temperature Effect on Output	≤0.0008% of Load/ °F
Non-Repeatability	≤0.01% FS
Zero Balance	≤1.0% FS
Insulation Resistance	>1000 MΩ at 50V dc
Compensated Temperature Range	-10° to +40°C
Operating Temperature Range	-18° to +65°C

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"Numbers Problem #4."...

Weighers.. % of full scale deflection. True accuracy at working load?

- **Load Cells..**
- For our example, consider a 5 cubic metre batch.
- Cement: 500 kg, Flyash: 500 kg.
- Total Cementitious: 1,000 kg weighed in a common weigh hopper.
- Hopper & gates weight: 450 kg
- Total load: 1,450 kg
- Load Cell selection: 2,000 kg.

- If the accuracy of the total system is +/- 1% of FSD,
- Potential Error: +/- 20 kg
- This means that at the cement weigh up point, the accuracy is only +/-20/500 = +/-4%
- Note that the Zero Balance is quoted as 1% of FSD or 20 kg.
- More commonly it is 2% or more.

- If all aggregates were weighed in one hopper, a 20,000 kg scale would be selected.
- An accuracy of +/- 1% of FSD is 200 kg which is +/-17% of the smallest ingredient, 63-40 mm.

- Thankfully, most systems are within +/-0.5%, so it is not always this bad.
- For Batching plants, cumulatively weighing ingredients has low individual accuracy.

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Factors affecting Batch Systems..

- Weigher accuracy & Weigher calibration.
- The weights of the individual ingredients are the only thing measured.
- The accuracy, repeatability and calibration of the weigher are critical.
- Does a weigher always tell the truth? Truth is relative to the calibration.
- Ask the guy who bought more accurate weigh scales for his wife for Christmas only to make her appear heavier.
- This affects both batch and continuous plants where weight methods are used.
- Calibrate Regularly!

Factors affecting Batch Systems..

- In Flight Material Correction.
- The flow from storage hoppers are variable with vessel geometry and the material itself.
- Affected by hopper angles, wall friction, and moisture content in finer materials.
- For cement and fly ash, the rate of discharge is affected by;
- Hopper design,
- Aeration,
- The head of fluidised material in the silo.
- Batch plants typically use aeration for discharge.
- Predictability is NOT a characteristic of the flow of aerated cement!
- Opening the gate for the same time results in differing amounts of discharged material each time.
- "In Flight Material" is not weighed until it arrives.
- A "pre act" factor is learned by the system from prior errors.
- It relies on repeatability of mass based flow rate (weight/time) from nothing more than a hole in the bottom of the hopper or silo.
- Every new batch is a new adventure playing by slightly varying rules.

Factors affecting Batch Systems..

- Affect of Air Pressure.
- Most batching systems operate gates pneumatically.
- Air pressure and resistance of the gate affect response.
- If air supply is marginal, loss and regain of pressure results in loss of repeatability of the "in flight" correction procedure.

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"Numbers Problem #5."...

Factors affecting Batch Systems..

- Cumulative Weighing or Individual Weighing.
- Each group of materials may be cumulatively weighed in a common weigh vessel.
- An error in one ingredient affects the accuracy of the remaining ingredients.

Non Linear Weigher	Recipe	Cumulative	Weigher Error	Cumulative Actual	Ingredient Quantity	Ingredient Error	Ingredient Error
Aggregate 1	500	500	-2.0%	490	490	-10	-2%
Aggregate 2	600	1100	0.0%	1100	610	10	2%
Sand	700	1800	1.5%	1827	727	27	4%
Aggregate 3	450	2250	2.0%	2295	468	18	4%
Total dry weight	2250	2250		2295			2.0%

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Factors affecting Batch Systems..

Cumulative Weighing or Individual Weighing.

Erratic Sand Flow 1	Recipe	Cumulative	Error	Cumulative Actual	Ingredient Quantity	Ingredient Error	Ingredient Error
Aggregate 1	500	500	0.5%	502.5	502.5	2.5	0.5%
Aggregate 2	600	1100	-0.5%	1095	592	-8	-1.3%
Sand	700	1800	3.0%	1854	760	60	8.5%
Aggregate 3	450	2250	0.5%	2261	407	-43	-9.5%
Total dry weight	2250	2250		2261			0.5%

Erratic Sand Flow 2	Recipe	Cumulative	Error	Cumulative Actual	Ingredient Quantity	Ingredient Error	Ingredient Error
Aggregate 1	500	500	0.5%	503	502.5	2.5	0.5%
Aggregate 2	600	1100	-0.5%	1095	592	-8	-1.3%
Sand	700	1800	-3.0%	1746	652	-49	-6.9%
Aggregate 3	450	2250	0.5%	2261	515	65	14.5%
Total dry weight	2250	2250		2261			0.5%

Factors affecting Batch Systems..

Cumulative Weighing or Individual Weighing.

Batch to Batch Variation, Erratic Sand Flow

	Recipe	Batch 1	Batch 2	Variation	Variation
Aggregate 1	500	502.5	502.5	0	0%
Aggregate 2	600	592	592	0	0%
Sand	700	759.5	651.5	-108	-15%
Aggregate 3	450	407.25	515.25	108	23%
Total dry weight	2250	2261.25	2261.25	0	0%

- Individual Weighers..
  - Advantages.
  - An error on one ingredient has no flow on affect to the others.
  - Faster weigh up time.
  - Measured batch is a greater % of the Full Scale Deflection.
  - Disadvantage.
  - Each weigher is different, so weigher to weigher errors carry over to all batches.

Factors affecting Continuous Systems.

- This is a "Rate Based System".
- A good continuous system achieves;
- All of the ingredients in the correct proportion one to the other at all times.
- Throughput can be increased or decreased during production.
- Precise "start-stop" performance for "batch" quantities.
- In such a system, absolutes are not so critical, but relationships are.
- Ingredients are metered against time.

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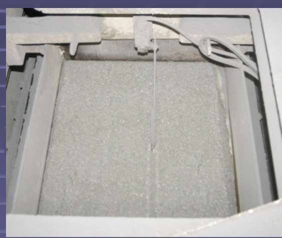
Factors affecting Continuous Systems.

- The primary initial measure is always dimensional.
- A further translation is required; kg/hr / kg/m3 = m3/hr where kg/m3 is the loose density of the particular ingredient material.
- Cross section of the feed stream is fixed.



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Factors affecting Continuous Systems.

- The movement of the metering device is divided up into increments such that each pulse represents a measured volume displacement.
- The metering parameter then becomes kg/pulse x pulses/hour.
- The metering rate is defined by pulses in unit time.
- The total mixed is the total of the pulses multiplied by the kg/pulse.

- If calibrations are correct, and speed control is accurate and smooth, this system offers superior repeatability.
- There are some variables however as in the batching system.

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"Numbers Problem #6."...

Density & Calibration.

Factors affecting Continuous Systems.

- Volumetric Calibration.
- A continuous system meters everything FIRSTLY by volume.
- Weighing can only take place after the material is metered, (as also in a batch system.)

- Unlike a batch system, withdrawal of the material from the storage vessel is (or should be) carried out in a very controlled and predictable manner rather than free fall from a hole in the bottom of the storage vessel.

- The "loose density" is the density as the metering feeder sees the material at the metering point.
- Material has been sheared off from a vertical direction to a horizontal direction and generally loosened.
- It is NOT the same as the loose density as developed in the lab, but is generally less.
- Obtained by actual calibration measurement of the real metering device.
- The "loose density" is always calculated to a dry density reference even though the calibration material may have included water.

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"Numbers Problem #6."...

Density & Calibration.
Factors affecting Continuous Systems.

- Volumetric Calibration.
- For aggregates and sand, three calibrations are usually sufficient to demonstrate repeatability.
- For cement and flyash, the samples are smaller, typically about 40 kg, so five or six samples are taken.

- When calibrating cement, the samples should be considered cumulatively.
- The exact stopping point of the feeder cannot be precisely controlled so that the cleat, vane or pulse sensor always stops in exactly the same place.
- The standard deviation approximates the difference due to cleat or vane spacing.

- Once these individual calibrations are completed, a well developed system will faithfully reproduce the required proportional rates of one feeder to the other even if sped up or slowed down.

- If the feed material is well controlled, these calibrations are repeatable.

"Numbers Problem #6."...

Density & Calibration.
Factors affecting Continuous Systems.

- The Matter of Density.
- Volumetric systems reference to the "loose dry density".

- **Coarse Aggregate.**
- If the grading and shape of aggregate varies, so does its density.
- This problem afflicts batch plants also, but in a different way.
- Whether referenced by volume or weight, variable shape alters the voids ratio of the mix.
- In a straight volumetric continuous system or a weight based batch you don't know that.
- **Fines.**
- Some fines are subject to bulking.
- At extreme dry or extreme wet conditions, the effective "Loose Dry Density" used for metering will alter.
- For normal included water ranges, the feed is uniformly loosened and the effective "Loose Dry Density" stable.

"Numbers Problem #6."...

Density & Calibration.
Factors affecting Continuous Systems.

- The Matter of Density..
- **Binder.**
- Cement and Flyash can be fluidized by aeration.
- When aerated, density & flow behaviour change drastically.
- Good systems do not aerate binders.

- Regular calibrations are needed until a pattern of variation is established.
- The metering behaviour of the machine does not alter, but input materials may.

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Factors affecting Continuous Systems.

- Hoppers & Silos.
- It is not possible to make perfect RCC from imperfect and highly variable ingredients.
- Neither a batch nor a continuous process can correct for variable shape, or indifferent grading.
- The continuous process has a better chance of doing so.

- To meter repeatably, the hopper design has to be free from "arching" or "bridging".
- The metering zone must be unaffected by material higher up in the hopper.
- Repeatability is VERY dependent on good hopper design.

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"Numbers Problem #7."... Weigh Belt Feeders.. What do they tell you?

Factors affecting Continuous Systems.

- **The recipe is defined in weight terms.**
- The general perception is that by metering on weight terms, the outcome will be more "accurate".
- The intervention of belt weighers introduces another set of variables.
- "Weight Rate" metering is often less uniform than a straight volumetric metering system.
- Belt weighers utilize a set of rollers mounted separately on a frame called a "weigh platform".
- The weigh platform is calibrated by adding known weights.
- The weight should be a roller of known mass set immediately over the weighing roller, calibrated with a moving belt.
- Rollers must be perfectly aligned, or belt tension will be weighed.

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"Numbers Problem #7."... Weigh Belt Feeders.. What do they tell you?

Factors affecting Continuous Systems.

- In a weigh belt feeder, material is usually restrained by side skirts.
- Other forces compromising the material weight measured on the weigh platform are;
- Side skirt friction,
- Granular interlock between the weighed and non weighed zone,
- Pressure on the weigh section from side skirts,
- Variable belt tension effect which is much greater on a feeder drawing from a hopper.
- The "Numbers don't tell you" what material weight is really on the weigh platform.

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"Numbers Problem #7."... Weigh Belt Feeders.. What do they tell you? Factors affecting Continuous Systems.

- Making it Work..
- A calibration with the actual material being metered is carried out.
- A "trimming factor" is applied to the measured weight value to make it represent an actual value for the material in question.
- This value may be anything from 0.9 to 1.1, although typically within +/- 5%.
- The belt weigher is calibration is material specific.
- If sand is fed from a hopper calibrated for coarse aggregate, the "numbers won't tell you" what you think they will.
- Such weighers require regular recalibration.
- The weight rate calculation is;
- Kg/hr = Feed width (m) x feed depth (m) x belt travel (m) / hour x density (Kg/cubic metre)
- A belt weigher is dynamic. The mass flow calculation is:
- Mass flow rate = mass x speed / weigh length.
- Units are; Kg/hr = (Kg x m/hr) / m

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"Numbers Problem #7."... Weigh Belt Feeders.. What do they tell you? Factors affecting Continuous Systems.

- Metering by "weight"..
- This means metering by mass flow rate.
- The cross section is fixed.
- The input variable is density.
- The controlled variable is speed.

- This approach requires a great deal of faith in the integrity of the weigher.

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"Numbers Problem #7."... Weigh Belt Feeders.. What do they tell you?

Factors affecting Continuous Systems.

- Since speed is then a dependent variable target, it is not practical to analyse the uniformity performance of that element of the control system.
- If the included water prediction for the fines is incorrect;
- Then the metered quantity of fines will also be incorrect.
- The moisture correction to the water feeds will also be incorrect.
- This approach brings out the disadvantage of the batch weighing approach without gaining from the advantage of uniformity afforded by the continuous system.
- The "numbers don't necessarily tell you" what you are really getting.

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Factors affecting Continuous Systems.

- Belt Weigher Accuracy..
- Most belt weigher manufacturers do NOT quote accuracy figures to any particular standard.
- Some manufacturers quote +/- 0.25%, but don't qualify it.
- Accuracy on compact belt weighers is less than for long conveyors.
- With regular calibration, they can offer an acceptable degree of repeatability.

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Factors affecting Continuous Systems.
Density Correlation and Correction.
A better approach..

- Calibrate the system on a volumetric basis.
- Control the speed accurately to a fixed target for a particular throughput.
- Use the weigh platform to monitor the feed material density.
- In this approach;
- The accuracy of the speed control can be monitored.

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Factors affecting Continuous Systems.
Density Correlation and Correction.
A better approach..

- If the measured weight of material changes for the predetermined calibration weight, then either;
- 1. The feed material grading is wrong.....Don't use it
- 2. Change in included water content.....Alter the water added, not the fines.
- 3. Wrong material in the hopper.....Stop immediately!
- 4. Blockage in the feed opening.....Stop immediately and clear it!
- 5. Arching within the hopper....Stop immediately and break the arch!
- None of these are reasons to alter the metering feeder speed!
- The density is displayed as a variation from target. Major errors demand intervention.

- Operated in this way, a weight enabled volumetric system gives power to control uniformity superior to either a weight based batch system or a "weight rate" continuous system.
- "Now the numbers can tell you something!"

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"Numbers Problem #8."...

Moisture Meters.. How good are they?

- Manufacturers of Moisture Meters are very reserved about specifying accuracy.
- Claims are general and mostly refer to repeatability.
- Accuracy is an absolute.
- Repeatability is an ability to return to a measure point, even if it is wrong.

- Main types;
- Electrical Resistance...Simple, but limited.
- Electrical Capacitance...Developed in France, but has difficulties.
- Infrared...Confused by sands of different colour.
- Microwave...Currently one of the better systems.
- RF attenuation...Suitable for liquids and pastes or finer materials.
- Nuclear...Accurate and repeatable, but not for general "on plant" use.

ARAN

"Numbers Problem #8."...

Moisture Meters.. How good are they?

- None of the common systems are even close to linear, but are typically exponential or asymtotic.
- Software interpretation is required.
- Accuracy is compromised at the margins.
- All are material specific and must be calibrated.
- Changing material mineralogy alters results, as much as 30% for constant moisture content!
- In a known case, included water of 4% when static read 7% in a moving stream
- Build up on the sensing face confuses them.
- Repeatability can be within +/- 1% of FSD.
- Accuracy depends upon calibration.
- The "Numbers will give a good idea, but continue to do lab moisture tests!"

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Factors affecting Continuous Systems.
Binder Metering.

- Fine particulates are difficult to meter on a continuous basis.
- With aeration, they flow like water.
- Some flyash is hygroscopic and does not flow at all!
- A successful binder feeder must;
- Be a positive displacement device.
- Prevent unrestrained flow from the silo.
- Deliver the same quantity per metering segment every time.
- A successful binder silo must;
- Ensure steady state flow without arching.
- Minimize the effect of head pressure.
- Re-loosen the binder to a repeatable state without inducing flooding.
- Maintain a negative pressure balance against filling.

- This is possible, but not always achieved.

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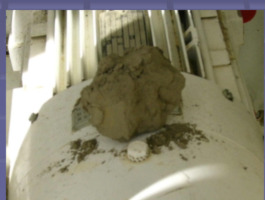
Factors affecting Continuous Systems.
Binder Metering.

- This flyash absorbed moisture and would not flow. A few minutes later, nothing could stop it!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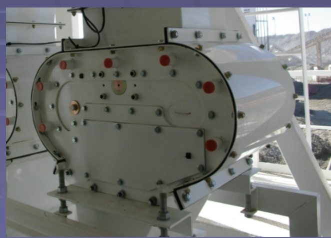
Factors affecting Continuous Systems.
Binder Metering.

- Binder Feeder Types.
- Augers...
- These are not positive displacement devices.
- Fluid binder can run through a stopped auger unimpeded.
- A poor choice.
- Rotary Vane Feeders...
- Positive displacement, but difficult to fill uniformly.
- Susceptible to build up of hydrated cement.
- Aran Cleated Belt Feeder...
- This is the best option for sealing, and repeatable displacement.
- If well calibrated and used with a matching silo, results are excellent.



Aran SiloFeed III Cleated Belt Feeder

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Factors affecting Continuous Systems.
Binder Metering.

- Binder Weighing Systems.
- Binder is usually weighed after metering in "weight rate" systems.
- Options are;
- Belt weighers...Accurate if well set up, but messy.
- Impact weighers...Quoted as Accuracy 0.5% of optimum? and Repeatability +/- 0.2% of rate.
- Coriolis weighers...Quoted as +/-0.5% (of what?)
- Post metering weighers are useful as a verification.
- Little value if the metering device preceding them is not highly repeatable.

- Loss of Weight Systems are also employed.
- Useful for checking calibration whilst operating.
- Must have effective sealing when isolated.

- All of these weight based systems must be calibrated.

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Mixers. What is their job?

- Mix together all ingredients thoroughly into a homogeneous product.
- Coat the stone and fines with binder.
- Distribute water evenly.
- Disperse additives.

- Macro Mixing..
- Getting unevenly distributed ingredients uniformly distributed within the mix.
- Micro Mixing..
- Distributing binder and fines evenly and at the micro level.

- For either batch or Continuous applications, Twin Shaft mixes are the only serious RCC option.

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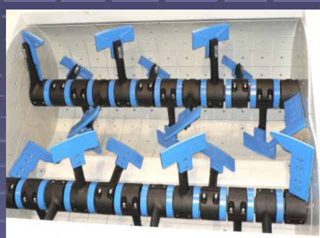
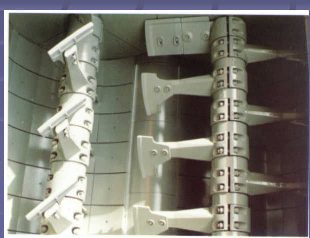
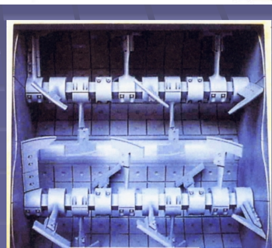
Batch Mixers.







Batch Mixers.

- There are many different configurations of mixing blades.
- Are all equally effective?
- Typically low speed, 25 RPM.
- Mixing is in the lower centre zone.
- Interleaving and folding process.
- Typical cycles are;
- Dose - 20 secs
- Mix - 30 secs
- Discharge - 20+ seconds
- Thoroughness of micro mixing is difficult to measure.

ARAN

"Numbers Problem #9."...

Batch Mixing Time. Are all mixers created equal?

- Mixing thoroughness is a function of;
  - Number of mixing blades,
  - Blade Size and shape,
  - Interleave pattern,
  - Speed,
  - Time.
- Mixing Time is not a Universal Number for all batch mixers.

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Continuous Mixers.

Continuous Mixers.

- There are several different mixing blade configurations.
- The main differences are in the phasing.
- In feed is largely macro mixed at arrival.
- High intensity mixers do a better job of micro mixing.
- Typical features are;
- Length; 3 to 4.5 metres
- Number of mixing elements; 40 to 76
- Speed; 70 to 110 RPM.
- Mixing is in the upper centre zone.
- Collision and division process.

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"Numbers Problem #10."...

Continuous Mixing Time. Less may be more!

- In a continuous mixer, material enters at one end and exits the other.
- Transit time is a function of;
- Mixing blade size,
- Mixing blade angle,
- Speed,
- Length.

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"Numbers Problem #10."...

Continuous Mixing Time. Less may be more!

- Mixing thoroughness is affected;
- Blade phasing,
- Sweep overlap,
- Collision intensity.
- Number of mixing interactions, or blade planes.
- High energy mixers run faster, mix more intensely, and produce superior homogeneity.
- Transit time is not a measure of mixing thoroughness.
- In a good mixer, "less can be more"

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What do the Numbers Tell You?

- There is no demonstrated evidence to support the superiority of one technology over the other.
- If well executed, both will work and give good results.
- Failure to understand either, or using them outside of their capabilities will produce inferior RCC.
- Which is the most efficient?
- The answer has to come down on the side of the system which is the smoothest, most compact, fastest to set up, and least costly.
- To my best engineering analysis, that is the Continuous System.
- If you want a batch system which is more than twice as big to do the same job, because it works only part time, then I can build you one of them to.

How does it affect me?

- Specification writers.
- Contractors.
- Site Engineers & Inspectors.
- Understanding the principles and limitations of each system will lead to better defined specifications, correct use of equipment, and more meaningful compliance procedures.

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