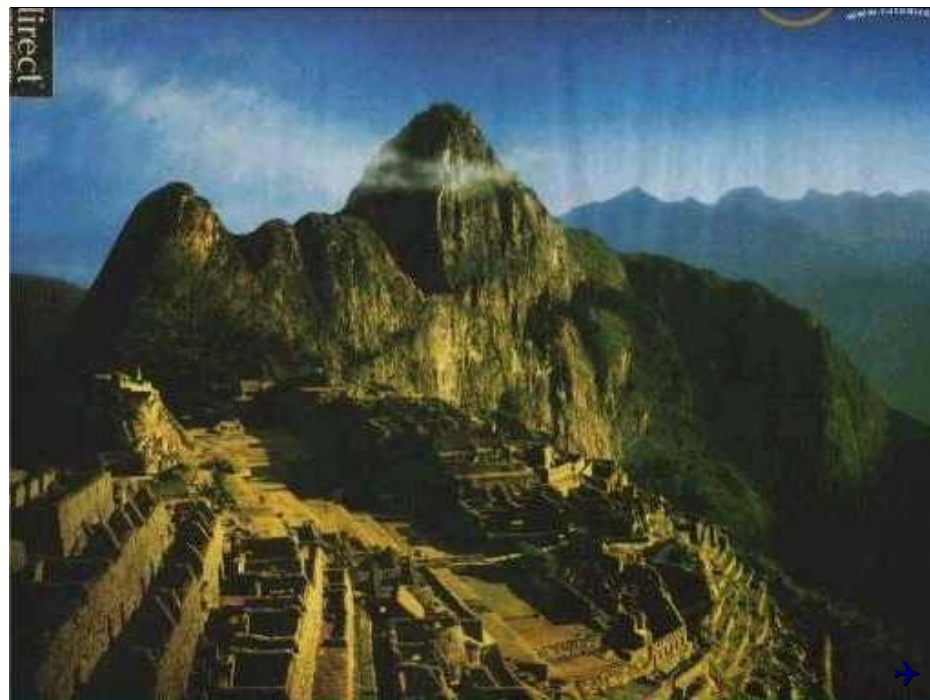
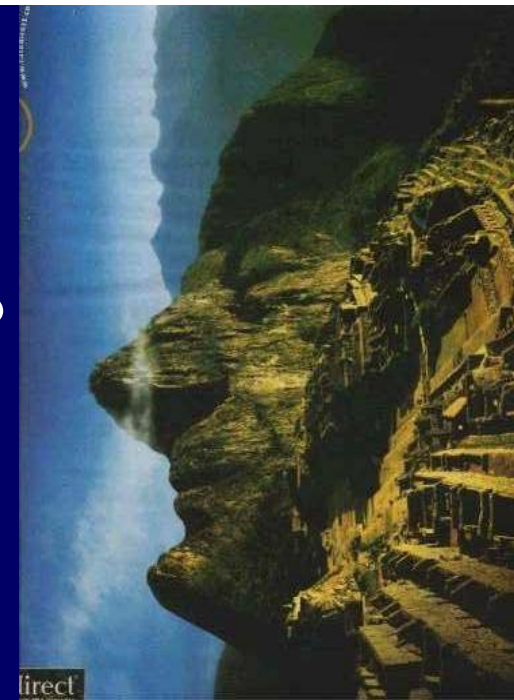


?????

?????



## VI ALACPA Airport Pavements Seminar & IV FAA Workshop

# “Quality Control/Quality Assurance of Airfield Pavement Construction”

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Senior International Consultant*

*São Paulo, 28 October 2009*



## Quality Control/Quality Assurance of Airfield Pavement Construction

**Introduction**

**Quality Assurance/Quality Control**

**Test Results Variability**

**Sampling/Testing**

**FAA QC/QA for Pavement Construction**

**Summary & Conclusion**



## Quality Control/Quality Assurance of Airfield Pavement Construction

**Introduction**



## Quality Control/Quality Assurance of Airfield Pavement Construction

**Introduction**

**Royal Cubit (523 to 525 mm)**

**["Côvado Real" (2700 B.C.)]**



**Construction accuracy =  
0.05 % (115 mm/230 m)**



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Introduction

Workers should bring standards for comparison against the Royal Cubit master  
(every full moon)

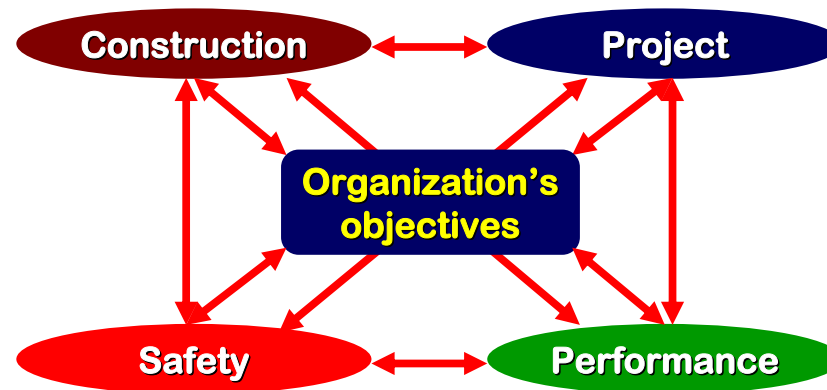
No compliance

DEATH



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Introduction



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Introduction

How do I control the quality?

How can I be sure that this link is OK?

How can I protect the contractor's interests?

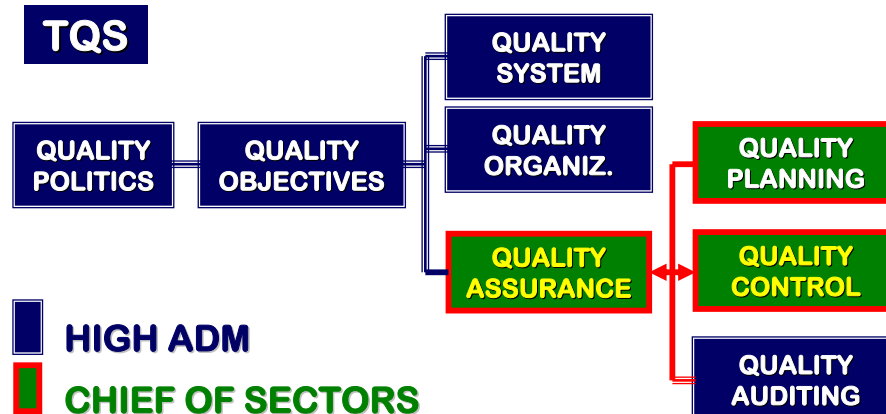
How can I protect the owner's interests?

Environment: HIGH STANDARD OF QC/QA (TQS)



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Quality Control/Quality Assurance (QC/QA)



## Quality Control/Quality Assurance of Airfield Pavement Construction

### QC/QA

QUALITY ASSURANCE

Its objective is to confirm if all the quality activities are being conducted as planned

Advanced stage of an organization that has practiced effective quality control in all the project/processes



## Quality Control/Quality Assurance of Airfield Pavement Construction

### QC/QA

QA is a system of external review and audit procedures conducted by personnel not involved in the process/activity

It assess the effectiveness of the QC program and the quality, accuracy, precision and representativeness of the process



## Quality Control/Quality Assurance of Airfield Pavement Construction

### QC/QA

**Quality Assurance (QA):** A set of activities to ensure that the development and/or maintenance process is adequate to guarantee that a system will meet its objectives.

**Quality Control (QC):** A set of activities designed to evaluate a developed work product.



## Quality Control/Quality Assurance of Airfield Pavement Construction

### QC/QA

QC team → Involved in finding defects

QA team → Involved in preventing defects

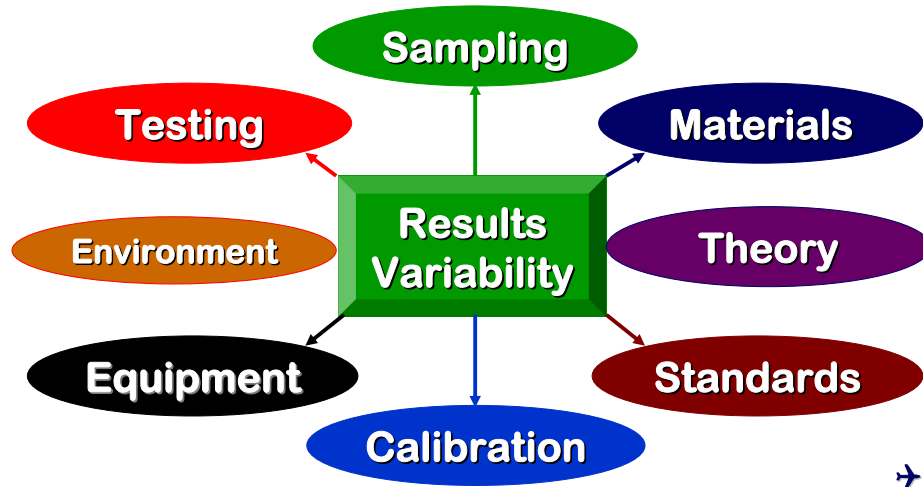
How much external QA/QC?

Depends on the project risk and the process maturity of an organization



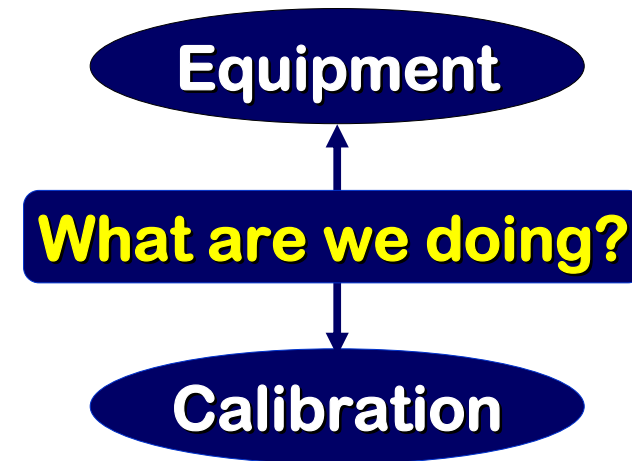
## Quality Control/Quality Assurance of Airfield Pavement Construction

### Test Results Variability



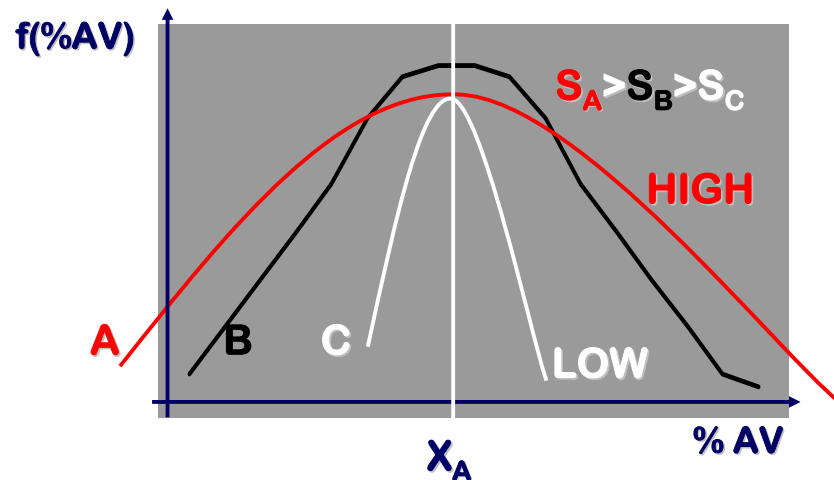
## Quality Control/Quality Assurance of Airfield Pavement Construction

### Test Results Variability



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Test Results Variability



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Sampling/Testing

#### Sampling

- (1) selection of a sampling plan which will provide the greatest amount of information at the least cost;
- (2) physical selection or gathering of samples in accordance with predetermined procedures for the preselected locations
- (3) testing; and
- (4) analysis of the data obtained.



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Sampling/Testing

#### Sampling

#### Representative sample?

All materials are subject to periodic variation

Different shipments, environmental conditions, lots, truck loads, car loads, or batches from a given supply will vary to some extent.

Material of any of the specific units will rarely be precisely homogeneous.



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Sampling/Testing

#### Sampling

A good Sampling Plan should be able to show:

Average characteristics of the material

Nature & extent of variability

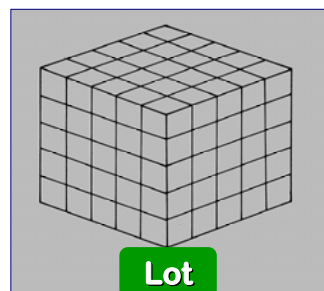
Trends & indicate need to change procedures/ processes to meet low % of defects



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Sampling/Testing

#### Random Sampling (Felix, G. - FAA)



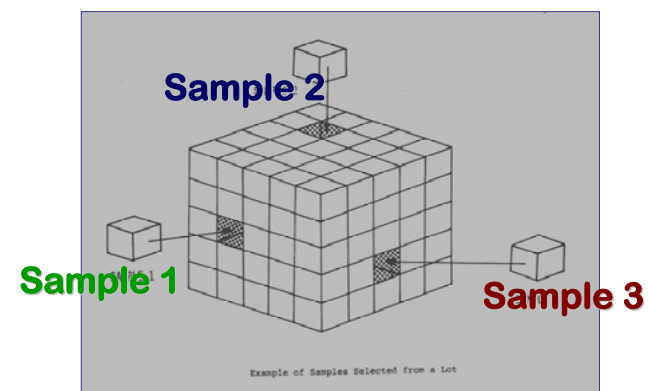
Same material  
Same process  
Same opportunity to be selected



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Sampling/Testing

#### Random Sampling



## Quality Control/Quality Assurance of Airfield Pavement Construction

### FAA QC/QA

AC 150/5370-10 – “Standards for Specifying Construction of Airports”

### Testing (Example for AC)

Plant produced material (as mixed in plant)

Field placed material (as laid down & compacted)



## Quality Control/Quality Assurance of Airfield Pavement Construction

### FAA QC/QA

### Sampling by time (Example)

Production duration: 10 h

Sub lots =  $10/4 = 2.5 \text{ h} = 150 \text{ min}$

Trucks will leave every 10 min (Assumption)

# trucks/sub lot:  $150/10 = 15 \text{ trucks/sub lot}$

Consider numbers from 1 to 15 (for selection)

Select one number/sub lot

Sample the truck as time selected



## Quality Control/Quality Assurance of Airfield Pavement Construction

### FAA QC/QA

### Sampling by weight (Example)

Lot size 2000 ton

Load/truck = 20 ton (Assumed)

Sub lot size:  $2000/4 = 500 \text{ ton}$

# of trucks/sub lot:  $500/20 = 25 \text{ trucks/sub lot}$

Consider numbers from 1 to 25 (for selection)

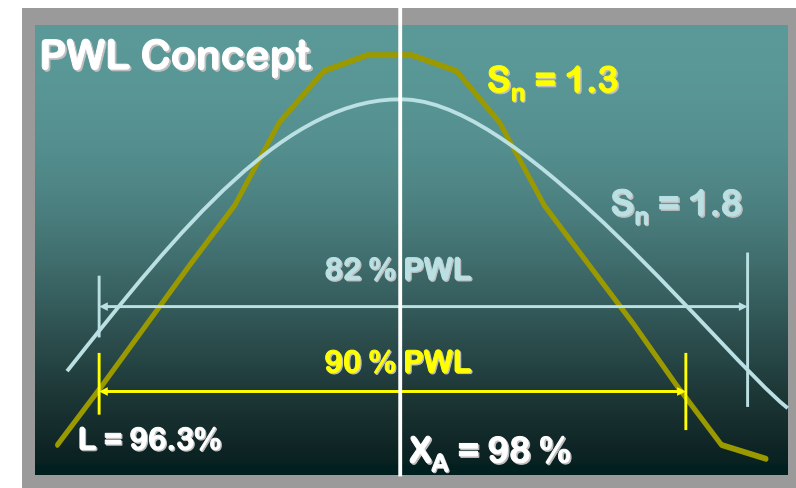
Select one number/sub lot

Sample the selected truck



## Quality Control/Quality Assurance of Airfield Pavement Construction

### FAA QC/QA for Pavement Construction



## Quality Control/Quality Assurance of Airfield Pavement Construction

### FAA QC/QA for Pavement Construction

Method for Estimating % of Material Within Specification Limits - PWL

#### Example AC Density, Lot "X"

1 - Divided in 4 Sub lots:

$X_1$ : 96.60  
 $X_2$ : 97.55  
 $X_3$ : 99.30  
 $X_4$ : 98.35  
 $n = 4$



## Quality Control/Quality Assurance of Airfield Pavement Construction

### PWL (FAA)

2 - Calculate average density for the lot:

$$A_x = (96.60 + 97.55 + 99.30 + 98.35) / 4$$

$$A_x = 97.95 \%$$

3 - Calculate the standard deviation for the lot:

$$S_n = [(96.60-97.95)^{1/2} + (97.55-97.95)^{1/2} + (99.30-97.95)^{1/2} + (98.35-97.95)^{1/2} / (4-1)]^{1/2}$$

$$S_n = 1.15$$



## Quality Control/Quality Assurance of Airfield Pavement Construction

### PWL (FAA)

4 - Calculate Lower Quality Index  $Q_L$  for the lot (Specified lower tolerance limit:  $L = 96.3$ )

$$Q_L = (A_x - L) / S_n \rightarrow Q_L = (97.95 - 96.30) / 1.15$$

$$Q_L = 1.4348 \%$$

5 - Determine PWL by entering Table 1 with  $Q_L = 1.44$  and  $n = 4$ )

$$PWL = 98 \%$$



## Quality Control/Quality Assurance of Airfield Pavement Construction

### PWL (FAA)

TABLE 1. TABLE FOR ESTIMATING % OF LOT WITHIN LIMITS (PWL)

PWL ( $P_L$ & $P_U$ )	Positive Values of Q ( $P_L$ & $P_U$ )							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
99	1.1541	1.4700	1.8714	1.8008	1.8383	1.9520	1.9994	2.0882
98	1.1524	1.4400	1.8016	1.8382	1.7812	1.8053	1.8370	1.8380
97	1.1496	1.4100	1.5427	1.8181	1.8381	1.8993	1.7285	1.7420
96	---	---	---	---	---	---	---	---
75	0.8185	0.7500	0.7223	0.7039	0.7009	0.6953	0.6922	0.6893
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
49	-0.0333	-0.0300	-0.0231	-0.0272	-0.0237	-0.0234	-0.0232	-0.0230
1	-1.1541	-1.4700	-1.8714	-1.8008	-1.8383	-1.9520	-1.9994	-2.0882





## Quality Control/Quality Assurance of Airfield Pavement Construction

### FAA QC/QA

#### Daily Inspections/Report should show:

- Technical specification item number/description
- Test designation, location, date, control requirements
- Adequate storage of materials/equipment
- Proper operation of all equipment
- Following plans & technical specifications
- Test results, causes of rejection, suggested actions, retests, etc.
- Review of QC tests
- Safety inspections



## Quality Control/Quality Assurance of Airfield Pavement Construction

### FAA QC/QA

#### Daily Test Reports

Before starting the next day's work period, the "owner" should receive the test results of the previous day's work period



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Equipments for QC/QA



The expense, size of the system, time needed to perform each test and data interpretation software make the system less practical for QC/QA (NCHRP 626, Jan 2009)

Conclusion for Highway



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Equipments for QC/QA



#### Light Weight Deflectometer

Weight (hammer) on a pole and the sensors (geophones) in a plate on the ground, connected to a handheld computer by wireless remote technology – Elastic modulus (NCHRP 626, Jan 2009)



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Equipments for QC/QA



**“The manual DCP is considered to have potential for QC use on a day-to-day basis....” (NCHRP 626, Jan 2009)**



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Equipments for QC/QA



**Physical cores correlated to the dielectric values measured by the GPR prior to and during construction (NCHRP 626, Jan 2009)**

**“This technology has limited use in QC applications, but greater potential for use in acceptable programs... (specially those for which thickness is included for pay factors)”...**



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Equipments for QC/QA

**Intelligent Compactor Roller (measure stiffness, temperature, compaction)**



**Hardware & software problems. These devices were not considered immediately ready for use in a day-to-day QA program (NCHRP 626, Jan 2009)**



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Equipments for QC/QA



**Nuclear density gauges with a value less than 1.5 pcf (0.024 g/cm<sup>3</sup>) (NCHRP 626, Jan 2009)**

**“Non-nuclear density gauges had repeatability values similar to nuclear density gauges with a value less than 1.5 pcf...”**



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Summary & Conclusion

QQ/QA

Test Results Variability

Equipment ⇔ Calibration

Sampling/Testing

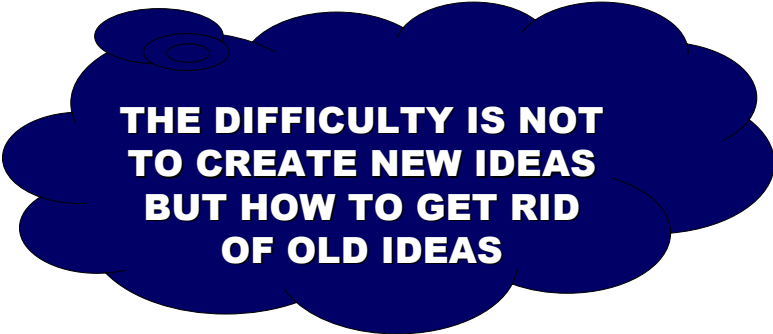
FAA QC/QA for Pavement Construction

Summary & Conclusion



## Quality Control/Quality Assurance of Airfield Pavement Construction

### Think About!!!



**THE DIFFICULTY IS NOT  
TO CREATE NEW IDEAS  
BUT HOW TO GET RID  
OF OLD IDEAS**



**MAYNARD KEYNES  
(ECONOMIST)**