



**British  
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

**Gateway to the Earth**

# **Construction aggregates : evaluation and specification**

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Industrial Minerals Specialist**



# Outline of presentation

- Minerals at the British Geological Survey
- Particle size, shape & density
- Strength testing
- Durability
- Characterisation
- Conclusions





# British Geological Survey

- National geo-survey focusing on public-good science and geological research.
- Our understanding of the subsurface helps society :
  - Use its natural resources responsibly
  - Manage environmental change
  - Be resilient to environmental change
- Over 500 scientists working with other 40 universities & institutes
- More information: [www.bgs.ac.uk](http://www.bgs.ac.uk)

# Minerals and me



Clive at a silica sand quarry in Hampshire

<http://www.bgs.ac.uk/staff/profiles/1159.html>

- Compile mineral statistics for UK, Europe and World (only 2 in the world do this!)
- Provide of spatial mineral resource information
- Carry out research (metallogenesis, land-use impacts of mineral extraction & resource security)
- BGS minerals information available as FREE downloads via [www.mineralsUK.com](http://www.mineralsUK.com)
- Industrial Minerals Specialist, 26<sup>th</sup> year at the BGS, travelled far and wide for mineral evaluation, and based at the HQ of the BGS in Keyworth



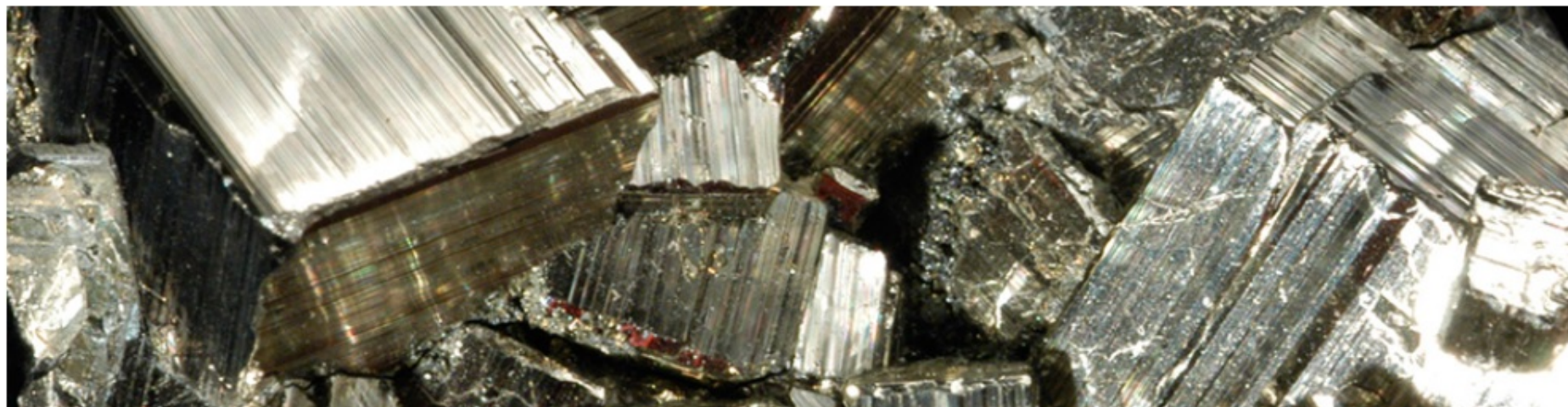




# MineralsUK

Centre for sustainable mineral development

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## Welcome to MineralsUK

MineralsUK is the British Geological Survey's [Centre for Sustainable Mineral Development](#). This website has a wealth of information on mineral resources, mineral planning, policy and legislation, sustainable development, statistics and exploration.

### Minerals & you

Economic minerals – here you will find out what they are, where they come from and why they are important.

### What's new

- [Opencast coal statistics 2013](#)
- [The development and implementation of mineral safeguarding policies at national and local levels in the UK](#)

### //Digital maps

A web-based Geographical Information System (GIS) has been produced to provide access to a range of Minerals Information Online.

[more info](#)



### //What's new

#### [Directory of Mines and Quarries 2014](#)

The Directory of Mines and Quarries 2014 is now available directly from BGS both as a free pdf download and as a digitally printed book.

[more info](#)



### //Downloads

#### [World Mineral Production 2009-2013](#)

The latest edition of this long running series is now available.

[more info](#)



# Aggregate testing : Introduction

- Sand and gravels and hard rocks used as aggregate are variable in quality & require testing
- Aggregate evaluation usually involves testing of physical & mechanical properties
- Tests simple / cheap to sophisticated / expensive
- BS & ASTM test methods usually apply







# Aggregate testing : Particle size distribution

- Grading is a key part of most aggregate standards
- Simple test, usually (wet or dry) screening
- Weight proportions retained used to produce cumulative frequency size distributions
- Well-, poorly & gap-graded aggregates
- Grading controlled properties



## Particle size analysis using screens





Smooth gravel road constructed from correctly graded aggregate (good blend of coarse and fine material)



Rutted gravel road constructed from incorrectly graded aggregate (too much coarse material)

# Aggregate testing : Particle shape

- Cuboidal' aggregate particles preferred
- Shape due to rock type, geology & production
- Poor shape largely due to inappropriate crushing equipment
- Flaky and elongate particle shape leads to poor aggregate and concrete performance
- Flakiness test
- Surface texture







Non-flaky  
particles



Flaky particles

# Aggregate testing : Density

- Bulk density is weight per unit volume ( $\text{kg/m}^3$ )
- Measured (loose or compacted) in containers of known volume
- Relative density is ratio of aggregate mass to mass of equal volume of water
- Water absorption also measured
- Pycnometer method for fines





## Density testing

Aggregate particle  
shape and density  
affects workability of  
concrete







Excessive flaky or rounded aggregate particles can cause concrete failure



Aggregate with high water absorption will require a larger proportion of cement to make concrete







# Aggregate testing : Strength testing (1)

## Aggregate Impact Value (AIV)

- Resistance to repeated & sudden force
- 14 - 10 mm aggregate hit 15 times with weight
- Proportion of <2.36mm (mean) is AIV
- The lower the AIV the stronger the aggregate
- AIV's <30 usually required



Aggregate  
impact  
value  
(AIV)





# Aggregate testing : Strength testing (2)

## Aggregate Crushing Value (ACV)

- Resistance to crushing by compressive force
- 14 - 10 mm aggregate compressed up to 400 kN
- Proportion of <2.36mm (mean) is ACV
- The lower the ACV the stronger the aggregate
- ACV's <35 usually required



## Aggregate crushing value (ACV)





# Aggregate testing : Strength testing (3)

## Ten Per cent Fines Value (TFV)

- Alternative to ACV
- Measures load required to give 10%  $<2.36\text{mm}$

## Los Angeles Abrasion Value (LAAV)

- Measures resistance to attrition
- Weight proportion  $<1.6\text{mm}$  is LAAV
- Similar to AIV / ACV



Los  
Angeles  
abrasion  
value  
(LAAV)



# Aggregate testing : Durability

## Aggregate Abrasion Value (AAV)

- Measures resistance to surface wearing
- 14 - 10 mm aggregate mounted in resin and weight loss % after abrasion test is AAV

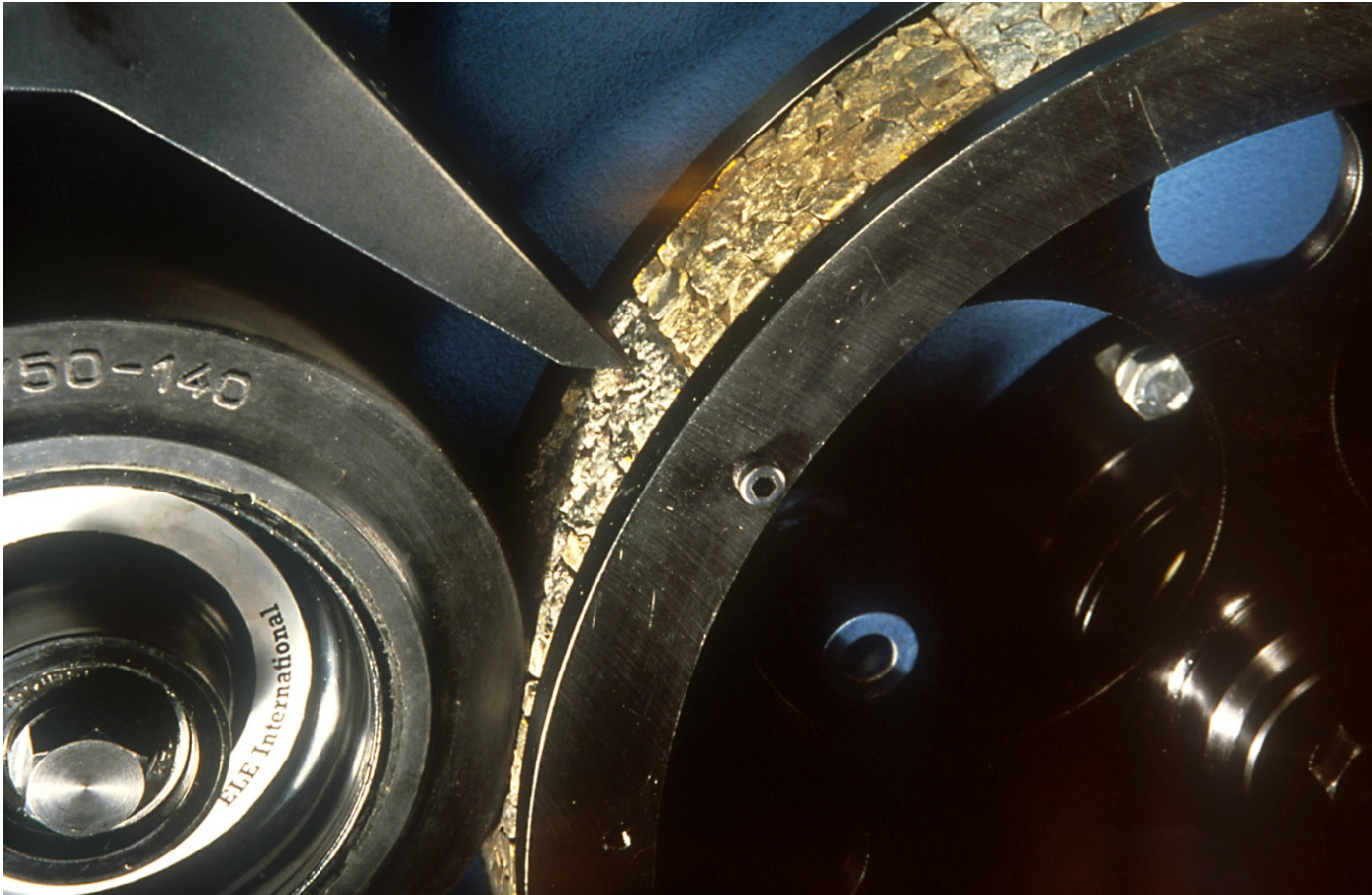
## Polished Stone Value (PSV)

- Similar to AAV, measures resistance to polishing
- Increasingly important for non-skid road surfaces

## Aggregate abrasion value (AAV)







## Polished stone value (PSV)

# Road construction



Wearing course (bound high PSV aggregate)  
in contact with traffic, skid resistant 40mm

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Base course (bound high strength  
aggregate) load bearing, impervious to  
water 60mm

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Roadbase (bound high strength aggregate)  
load bearing and spreading 100mm

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Sub-base (unbound high strength  
aggregate) load spreading during  
construction, drainage 150mm

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Capping layer (low grade aggregate)  
working platform 100mm

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Ground surface

Section through a  
typical macadam  
bound road – not  
to scale



Road surface  
suitable for heavy  
traffic



Hot Rolled Asphalt Wearing Course,  
35%/14mm. Design, with 20mm. high PSV precoat,  
After 8 years on the A5,





# Aggregate testing : Soundness

## Magnesium Sulphate Soundness Value (MSSV)

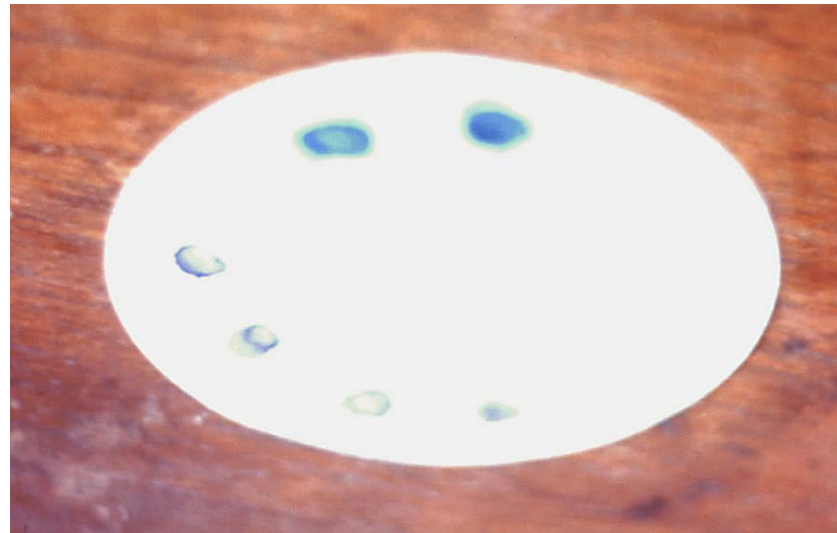
- Measures resistance to weathering
- Simulation of repeated freeze-thaw action

## Methylene Blue Absorption Value (MBV)

- Measures clay content of aggregate
- Amount of organic dye absorbed is proportional to clay content



## Methylene blue absorption value (MBV)



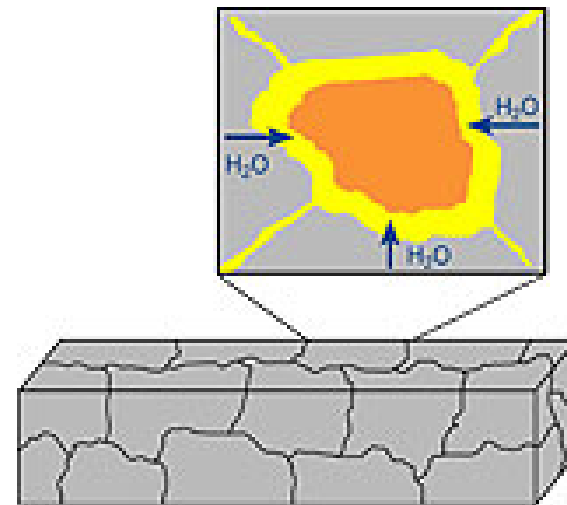


Stripping of stone chippings from surface of road caused by dust/ clay coating on aggregate particles



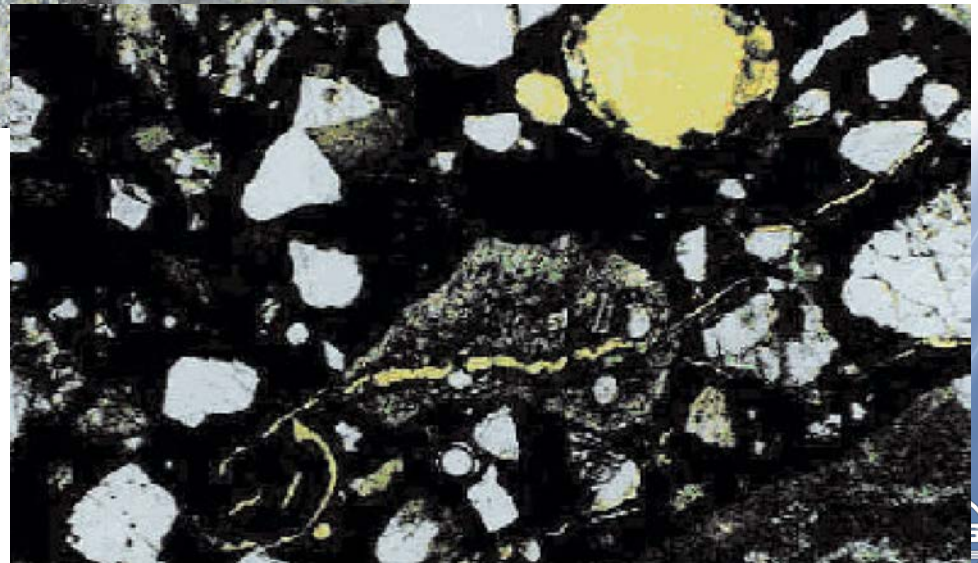
# Aggregate testing: Alkali-silica reactivity (ASR)

- Reaction between reactive silica and hydroxyl ions in alkaline conditions caused by saturated cement
- Swelling gel formed that may lead to expansion & cracking in concrete
- ASR risk from rocks volcanic rocks containing volcanic glass or opaline silica
- Identification of reactive silica by petrographic, physical or chemical analysis





Concrete affected by  
alkali silica reaction  
(ASR)



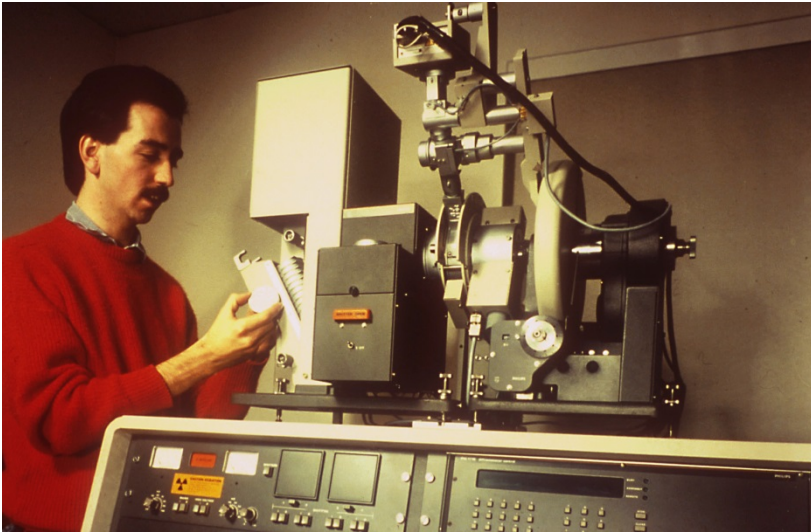


# Aggregate testing : Additional characterisation methods

- Petrographic analysis
- X-ray diffraction (XRD)
- X-ray fluorescence (XRF) spectrometry
- Scanning Electron Microscopy (SEM)
- Electron Microprobe
- Thermal Analysis
- Particle-size distribution
- Petrographic Image Analysis



## Additional testing methods

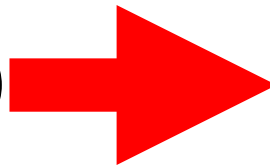




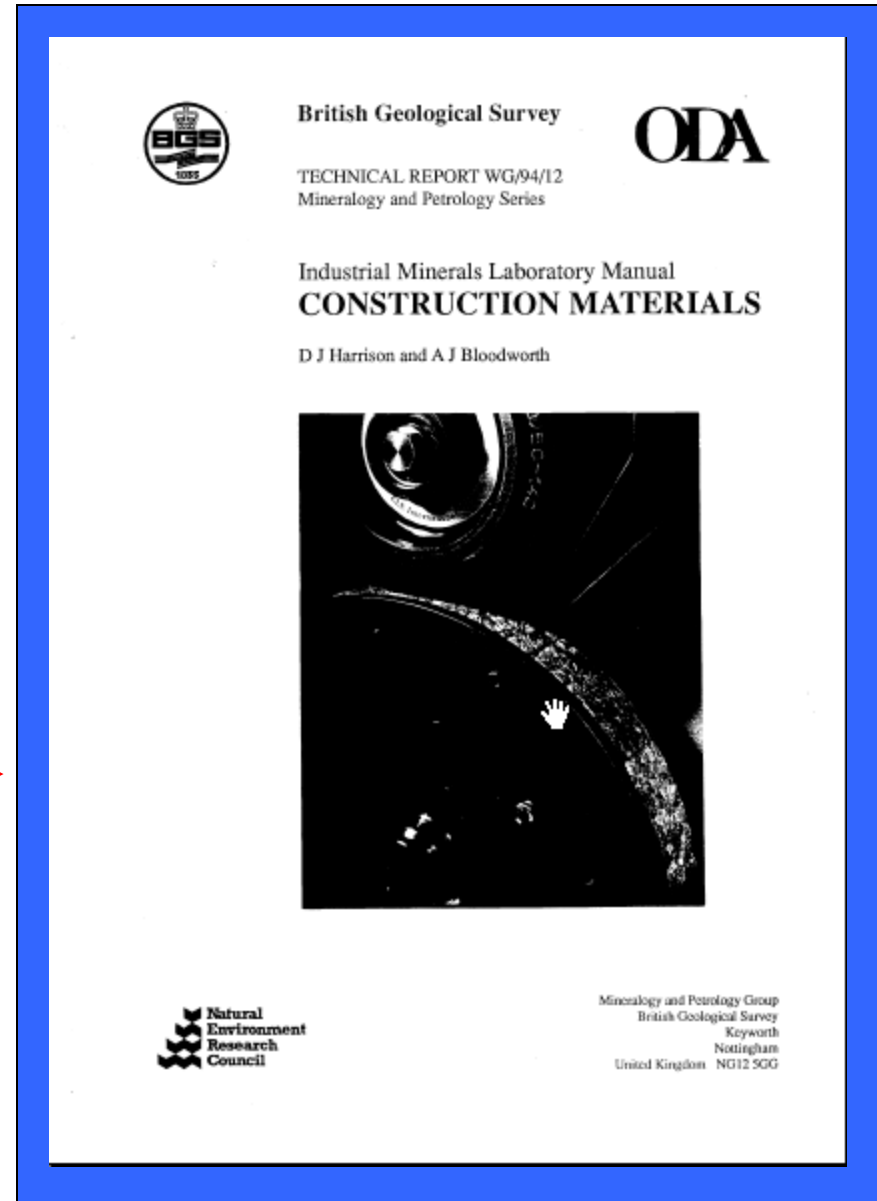
# Conclusions

- Sand and gravels and hard rocks used as aggregate are variable in quality & require testing
- Lack of testing and quality control of aggregates has direct effect on quality and costs of construction.

For more on  
specifications and  
testing, see



- Download from  
[http://www.bgs.ac.uk/research/international/DFID-KAR/WG94012\\_COL.pdf](http://www.bgs.ac.uk/research/international/DFID-KAR/WG94012_COL.pdf)



# Thank you for your attention!



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