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Global Best Practices in Dams & Hydraulic Structures : Alkali–Silica Reaction

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We'll Talk About:

1. Introduction
2. Mechanisms
3. Consequences
4. Measurement Approaches
4. Monitoring of Dams
5. Case Studies
6. Computer Vision

Forms of AAR

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Alkali-Aggregate Reaction (AAR)

- Deterioration of concrete due to the reaction between alkalis and aggregate.
- Chemical reaction causes cracking.

Alkali-Silica Reaction (ASR)

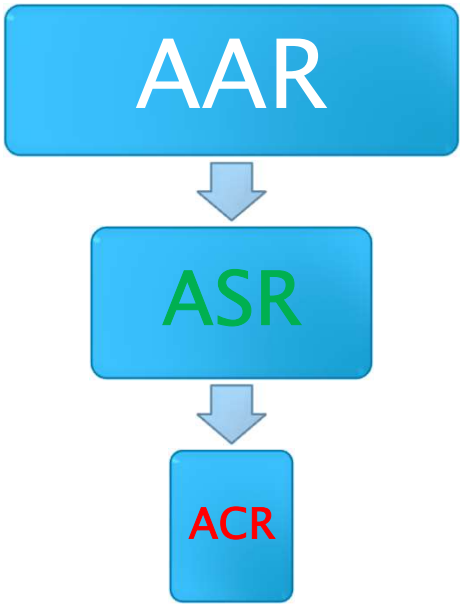
- Alkali + Silica
- Produces an Expansive Gel

Common

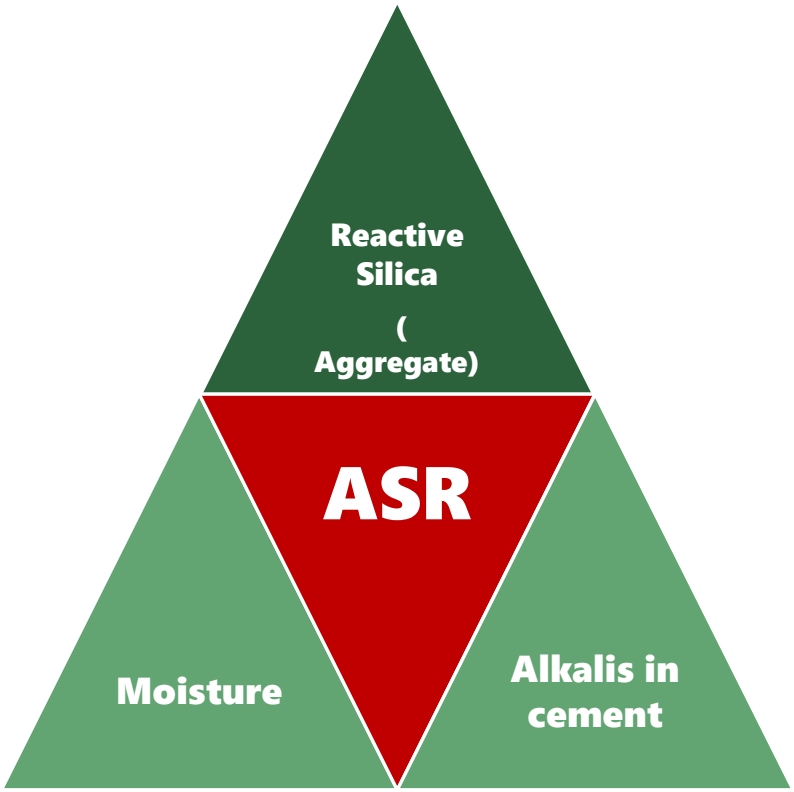
Alkali-Carbonate Reaction (ACR)

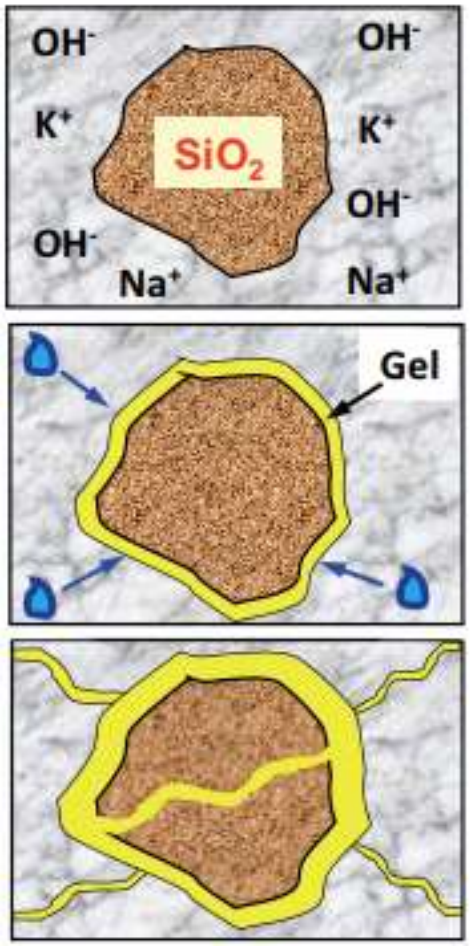
- Alkali+ Carbonates
- Leads to local carbonation

Scarce

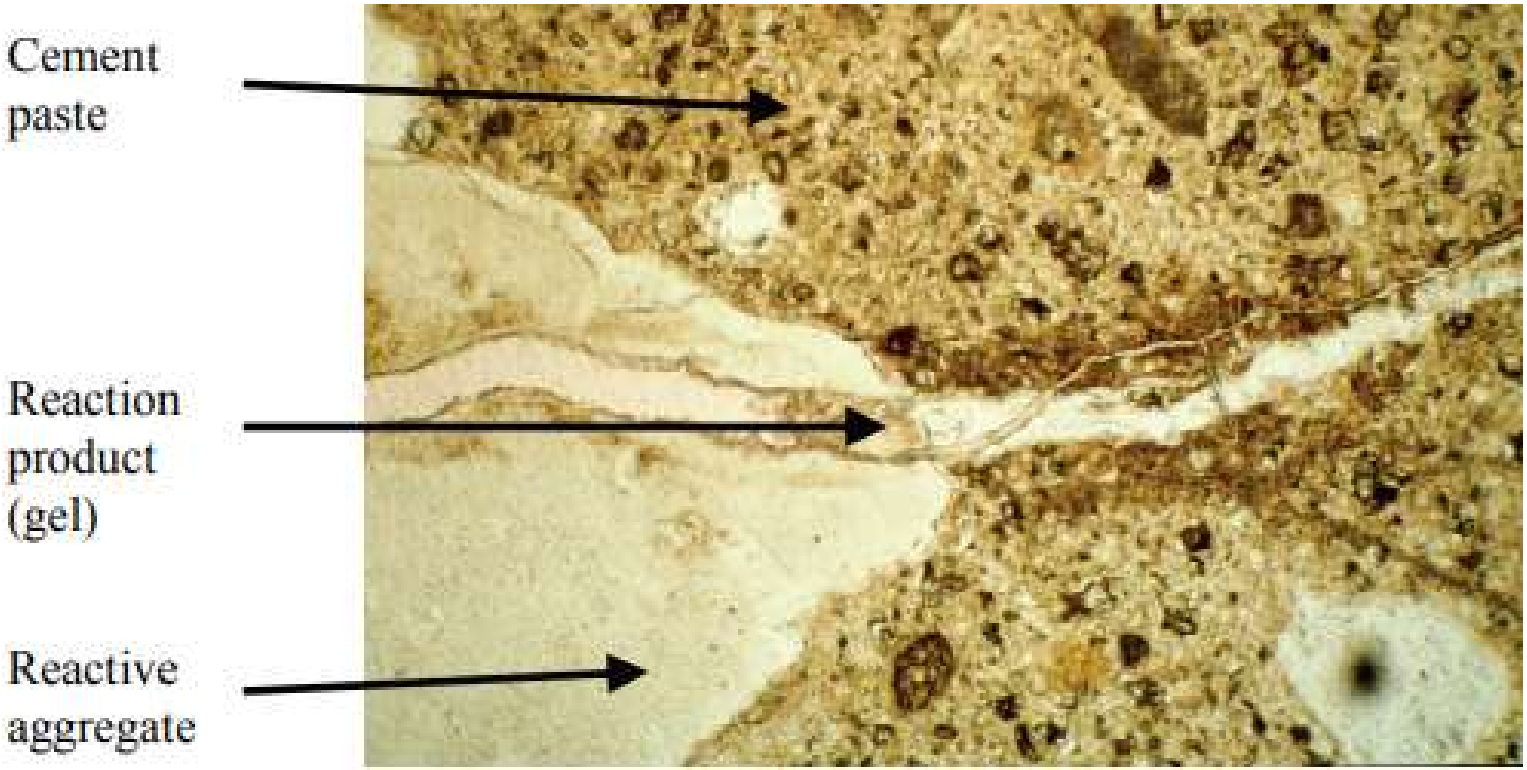


ASR FORMATION





ASR FORMATION



EFFECTS OF ASR

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❑ Structural effects

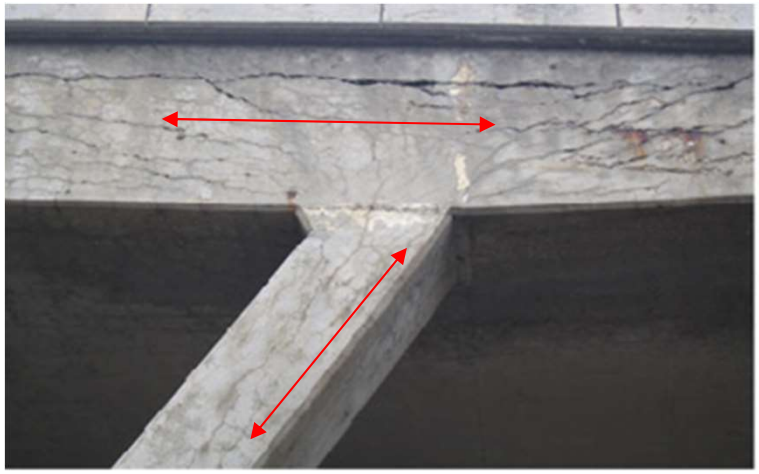
- Cracking
- Strength reduction
- Stiffness reduction
- Strain in reinforcements
- Excessive deflections

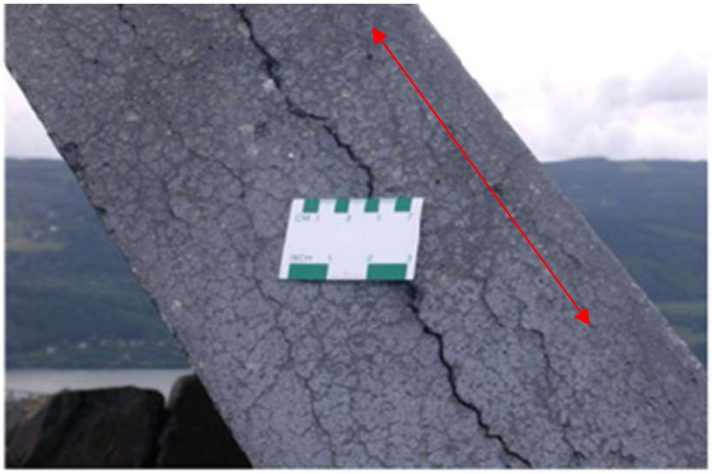
❑ Durability effects

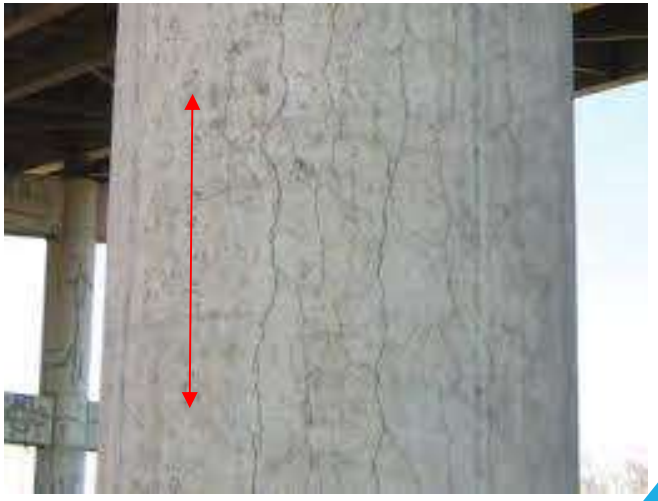
- Promotion of carbonation
- Rebar corrosion
- Strain in steel

VISUAL SIGNS

- **Structure**
  - Crack Pattern
  - Crack widths
  - The stress flow







VISUAL SIGNS

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- **Core Samples**
  - **Crack Pattern: Aggregate, Cement, At interface**
  - **Crack widths**
  - **ASR Gel**

POPULAR METHODS

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Displacement

Moisture/Water Content

Concrete Strains

Fiber Optic Sensors

POPULAR METHODS

Temperature

RDT

Mechanical Properties

AE SENSOR

Crack Mapping

Cracking Index

POPULAR METHODS

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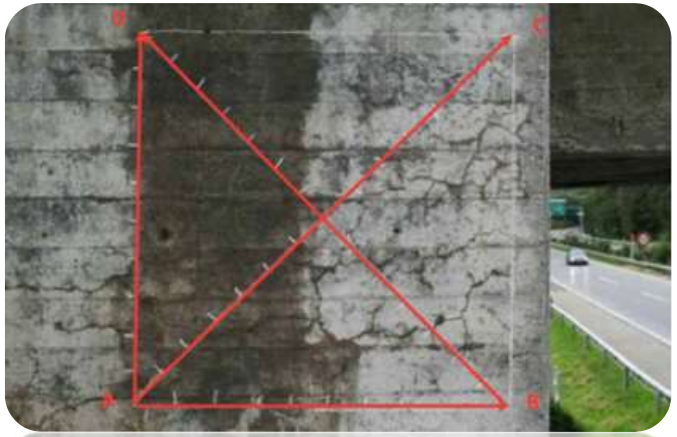
- Visual Inspection
- Monitoring Equipment Operations
- Unmanned Aerial Systems Photogrammetry (UAS)
- Analysis of Recorded Data
- Crack Mapping



VISUAL INSPECTION

Relative Displacements

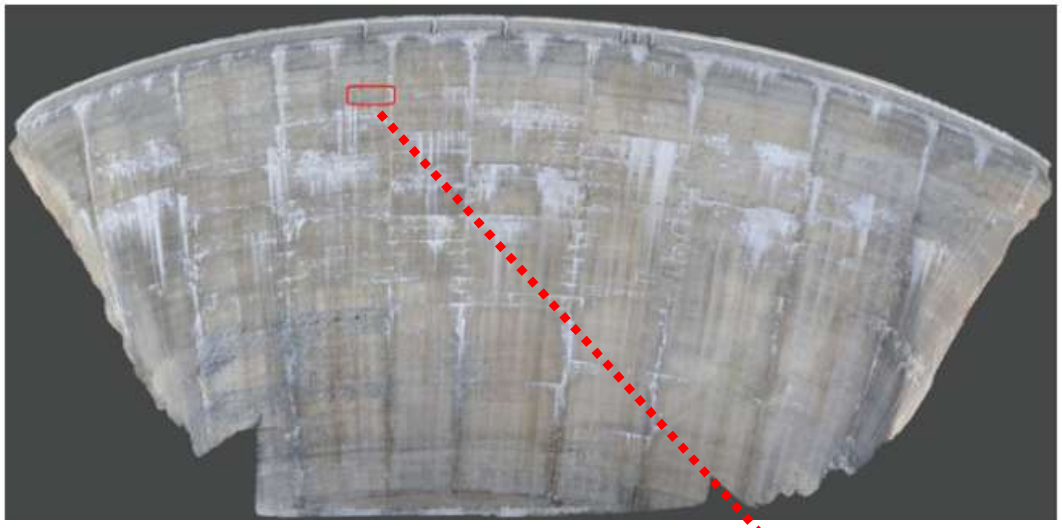
Cracks

Spalling
Vertical Contraction joint

Deterioration on dam face

Damage to embedded mechanical equipment

Changes in spillway gate side seal gap



10-12 m distance

Enlargement of Image

ANALYSIS OF RECORDED DATA

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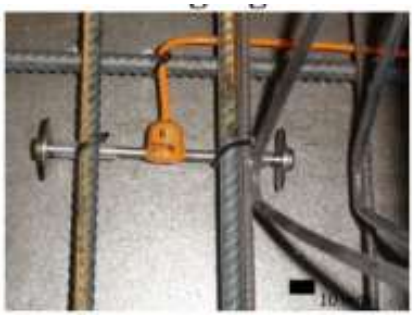
❑ Environmental Data

- ❑ Temperature Measurement
- ❑ Moisture Monitoring
- ❑ Reservoir Water Surface Level



Embedded Sensors

Water Level Indicator

CRACK MAPPING

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- UAS photogrammetry
- P-Wave Seismic Refraction
- Spectral Analysis of Surface Waves (SASW)
- Electrical Resistivity Tomography (ERT)

CRACK MAPPING

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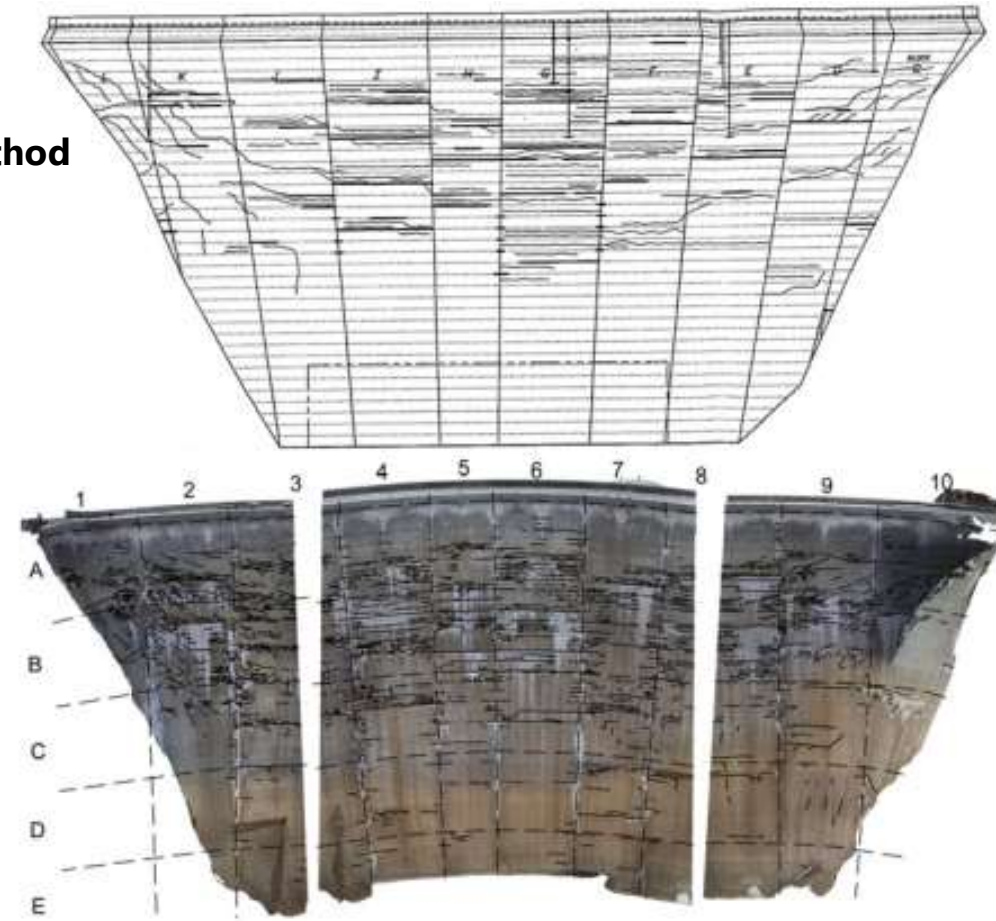
❑ UAS photogrammetry

Traditional Method



Photogrammetry Method (20 yrs. later)

CRACK MAPPING

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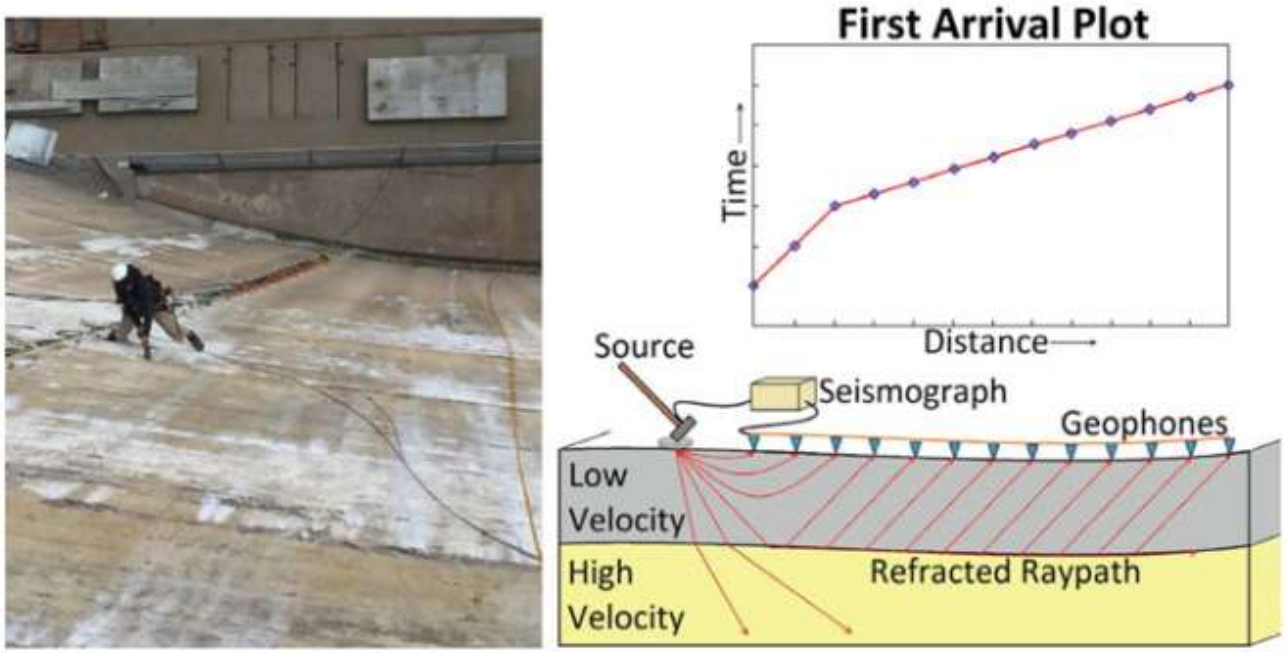
❑ P-Wave Seismic Refraction



P-wave seismic refraction test setup at Seminoe Dam

SAUNDERS GENERATING STATION

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Measurement of Physical state

- ❑ Crack mapping
- ❑ In-situ rebar stress tests
- ❑ Coring tests and crack mapping
- ❑ of boreholes.

Measurement of concrete swelling:

- ❑ Pendulum data (Displacement)

STUDY ON DAMS IN FRANCE (BY EDF)

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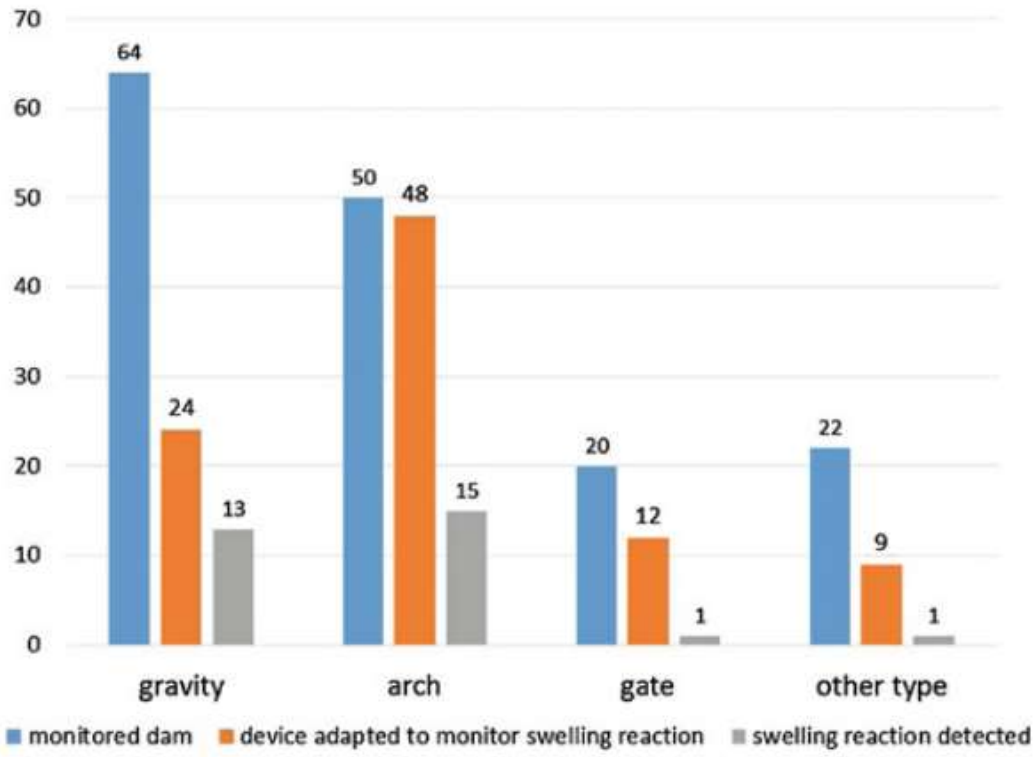
- Stress measurement
- Non-destructive Tests
- Physical, and petrographic properties



DEEP LEARNING

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Convolution Operation in CNNs

0	0	0	0	0	0	0
0	1	0	0	0	1	0
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	1	0	0	0	1	0
0	0	1	1	1	0	0
0	0	0	0	0	0	0

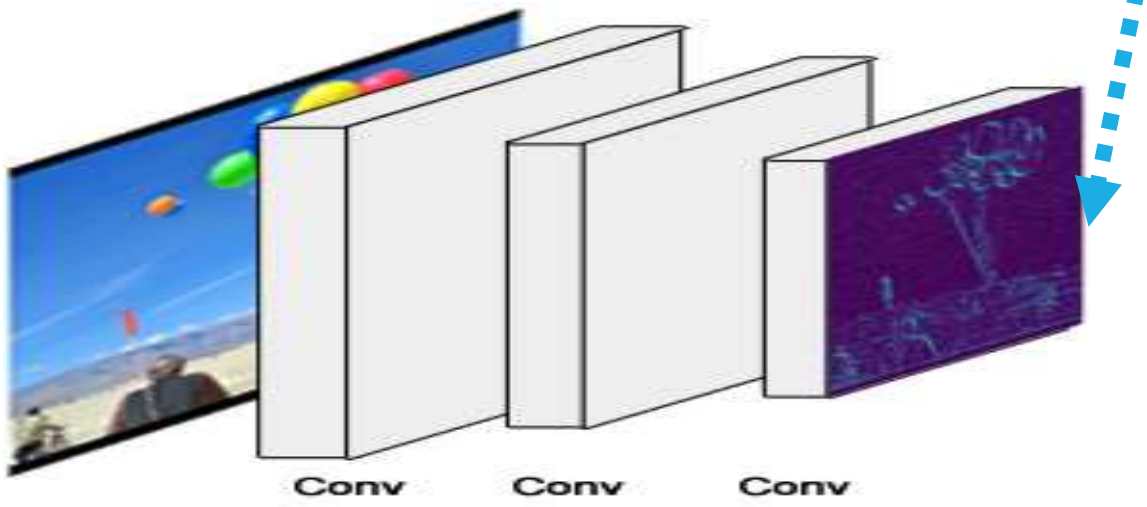
$\otimes$

0	0	1
1	0	0
0	1	1

$=$

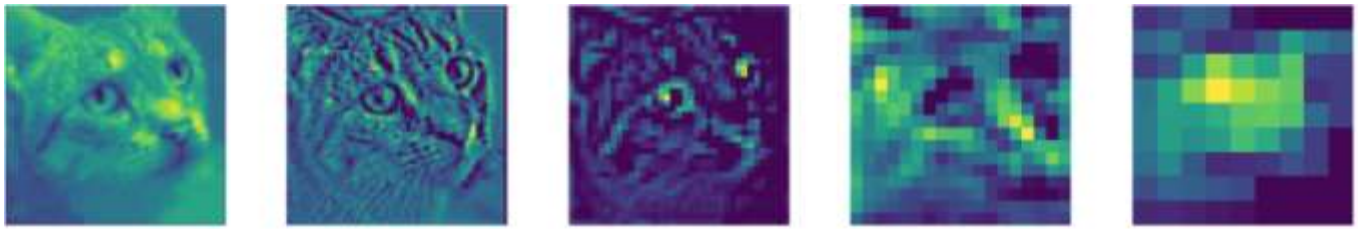
0	1	0	0	0
0	1	1	1	0
1	0	1	2	1
1	4	2	1	0
0	0	1	2	1

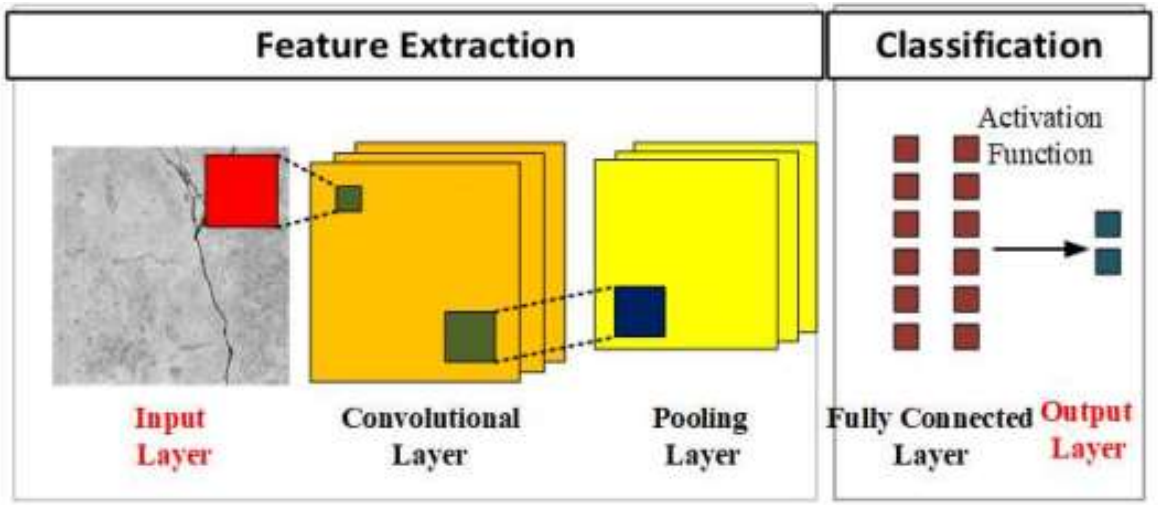
Input Image (Matrix) **Filter** **Feature Map**



DEEP LEARNING

Low level Features → **High level Features**





Typical architecture of a CNN

APPLICATIONS IN DAMS

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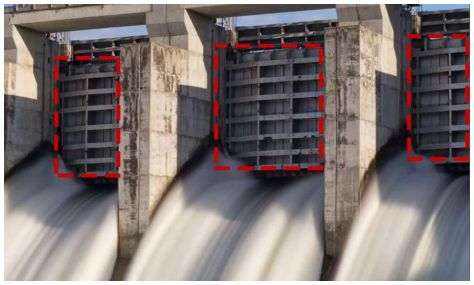
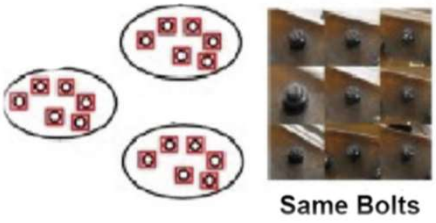
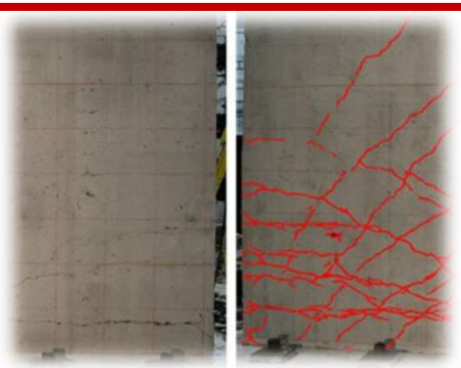


Gate Detection



Object Grouping



Crack Segmentation

Crack Classification

UAS-BIM PLATFORM

AUTODESK® RECAP™

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Aerial Photos → 3D models

REFERENCES

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THANK YOU

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