

# The Importance of Non-Destructive Evaluation (NDE) & Measured Building Survey (MBS) when assessing Tall Structures

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# PRESTIGIOUS TALL BUILDINGS



# NOT SO PRESTIGIOUS...



**Tall Buildings?**  
It's all relative...



# New York City



# Bury St Edmunds, England



**Older Buildings** more frequent:







# NDE - tall buildings?

COMMON TOOLS

Why...?







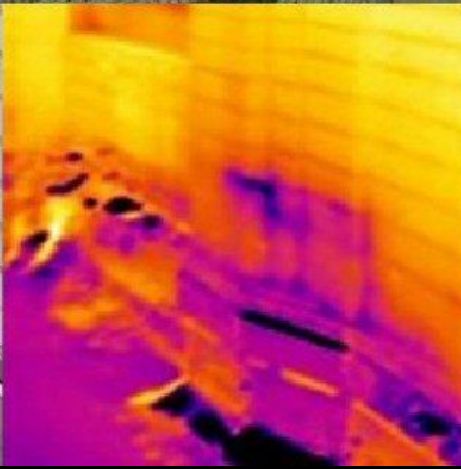


# NDE - tall buildings?

COMMON TOOLS

## Most Common





**Leaks**

# What is NDE?

INVESTIGATION BELOW THE SURFACE



# Actually... Its Using **Technology** (and ingenuity) to **Provide Information** about **Hidden Structure**





**1. INFRARED THERMOGRAPHY**

2. IMPULSE RADAR [GPR]

3. ACOUSTICS

4. MAGNETIC METHODS  
[METAL DETECTORS]



# THERMAL IMAGING

## OVERVIEW

**THERMOGRAPHY IS THE PROCESS OF  
ACQUIRING AND ANALYZING THE  
SURFACE TEMPERATURE OF AN  
OBJECT.**

No Other Tricks Involved...

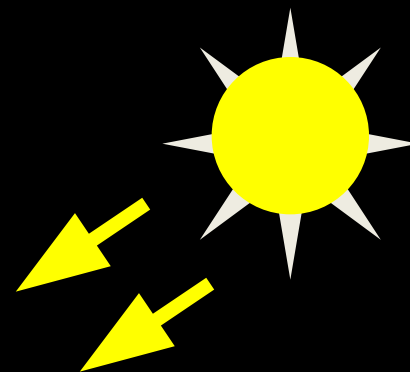
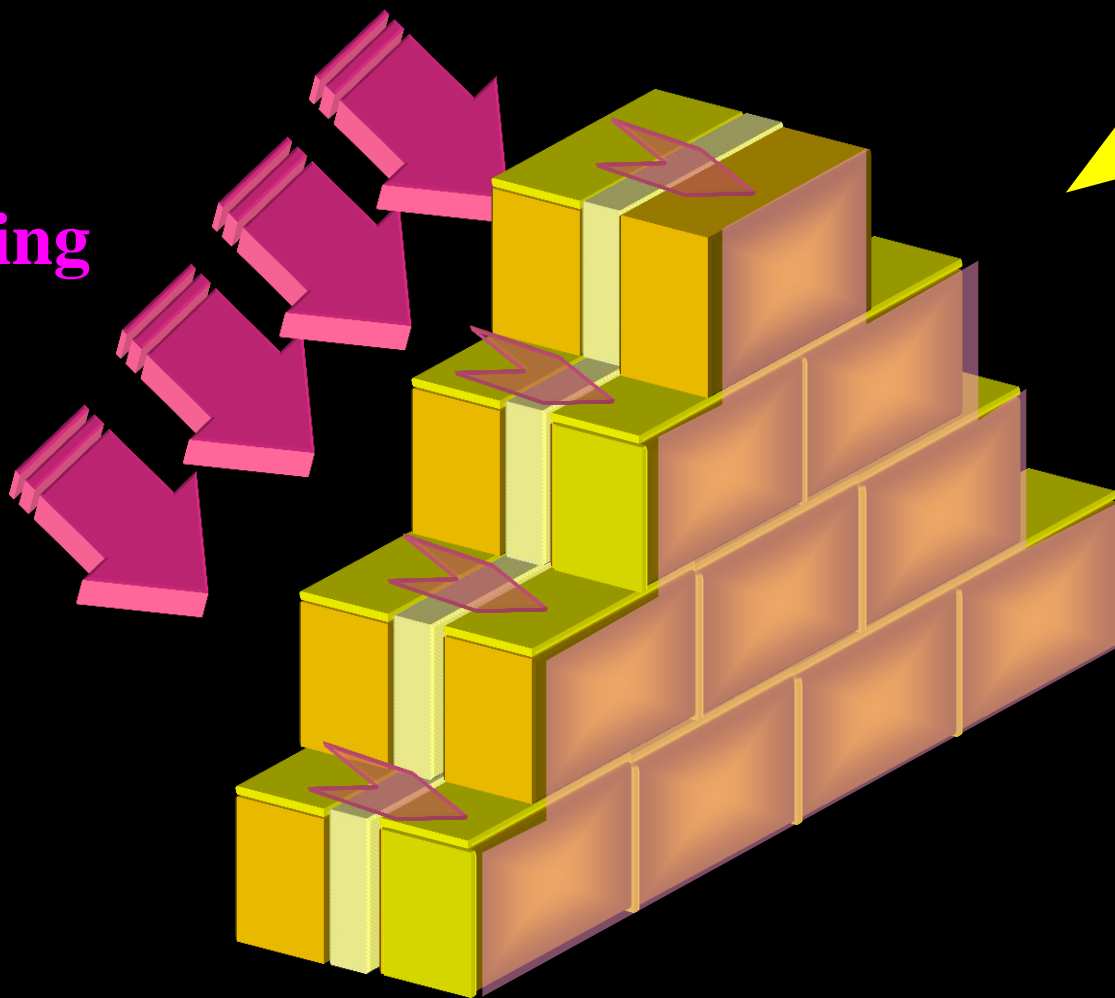


# THERMAL IMAGING

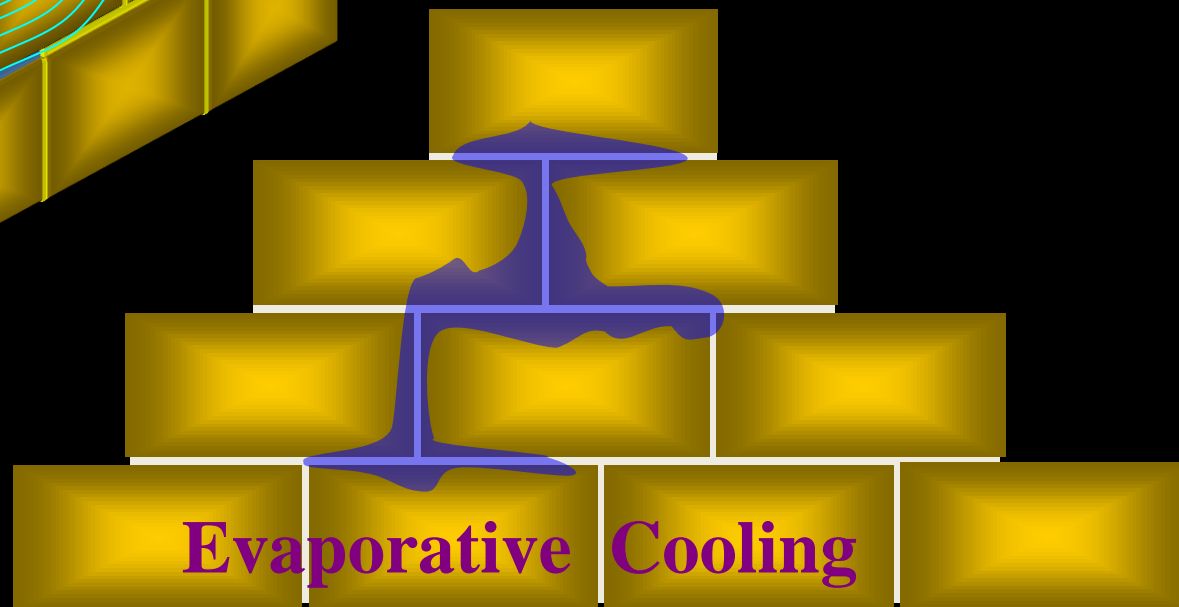
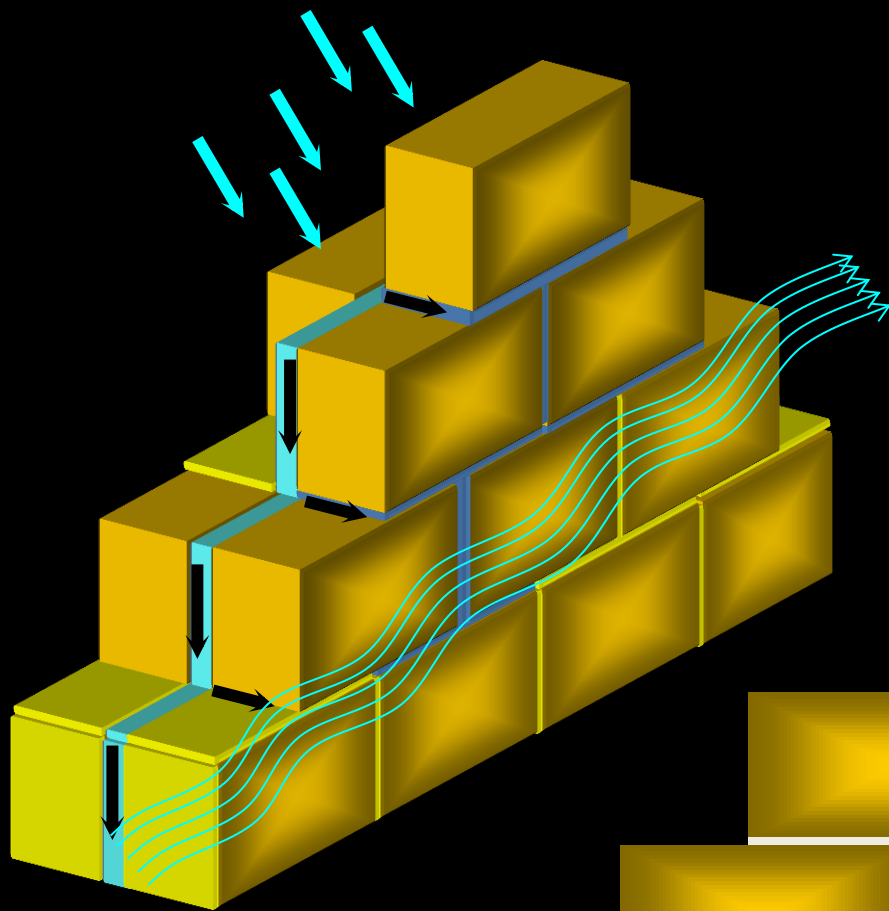
## DATA COLLECTION



**Heating**



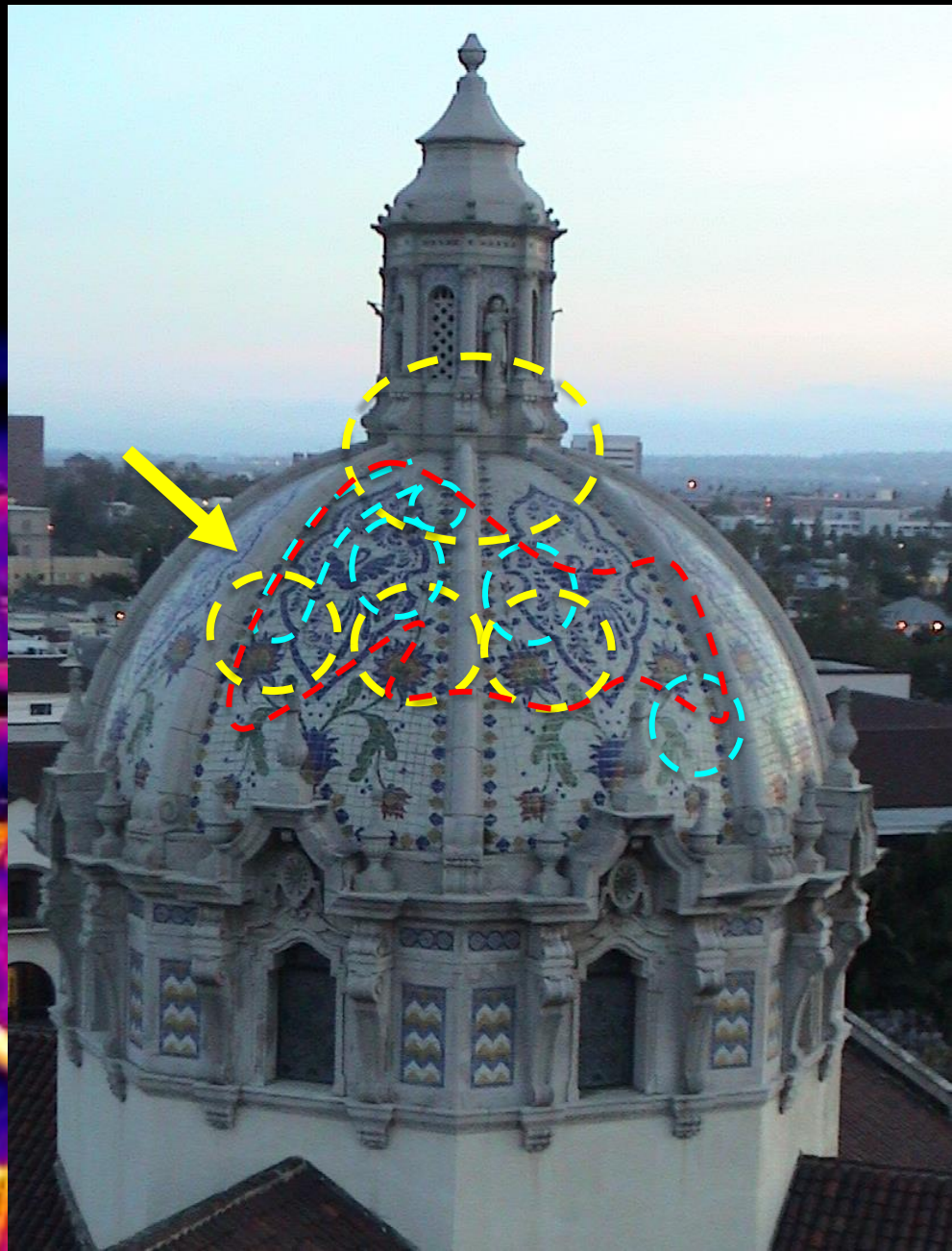
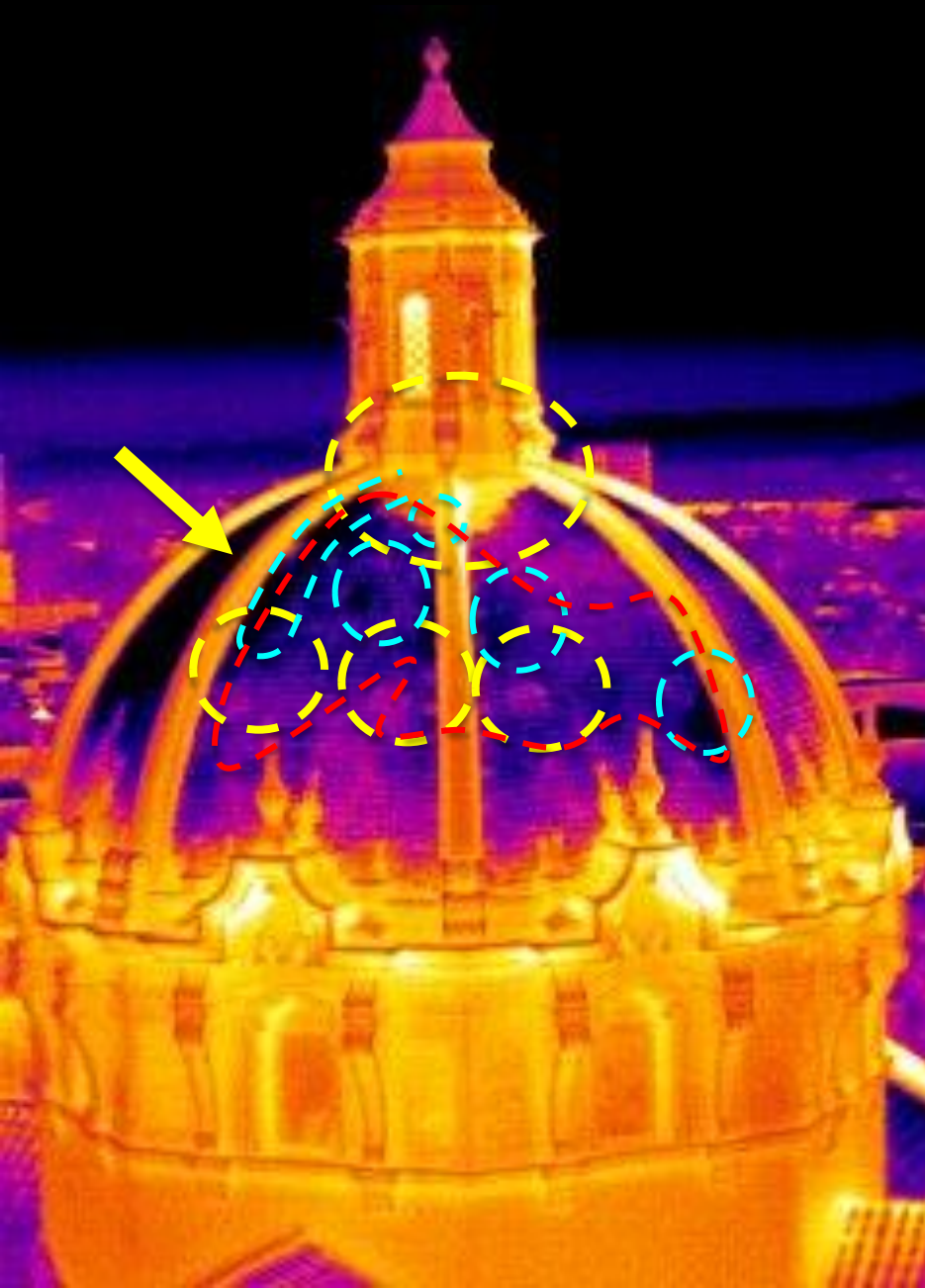
**Solar**



# Critical Info...

Technology *Does not*  
*necessarily*  
*make anything better*

# Interpretation



1. INFRARED THERMOGRAPHY

**2. GROUND PENETRATING RADAR [GPR]**

3. ACOUSTICS

4. MAGNETIC METHODS [METAL  
DETECTORS]





# GROUND PENETRATING RADAR [GPR]

## OVERVIEW

**GROUND PENETRATING RADAR USES RADIO WAVES TO ASSESS THE FORM AND CONDITION OF SUBSURFACE STRUCTURE.**

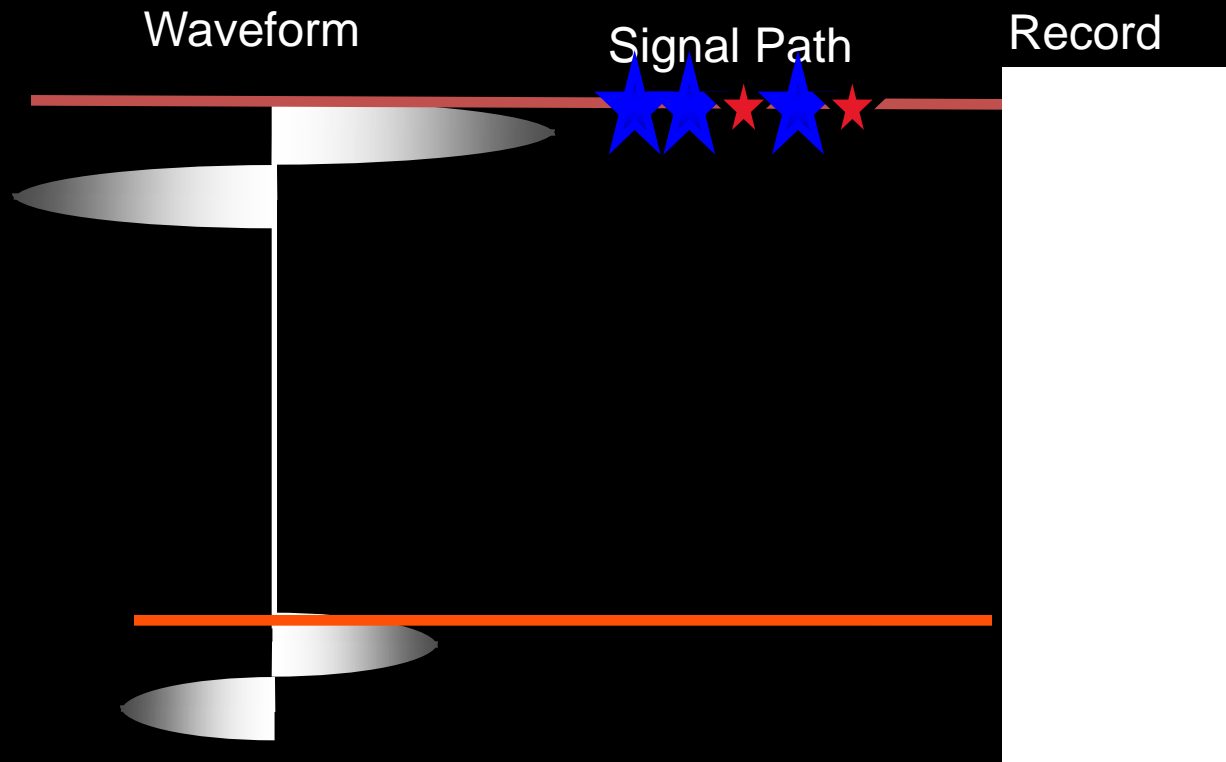


# GROUND PENETRATING RADAR [GPR]

COLLECTION



# Radio Echo Sounding



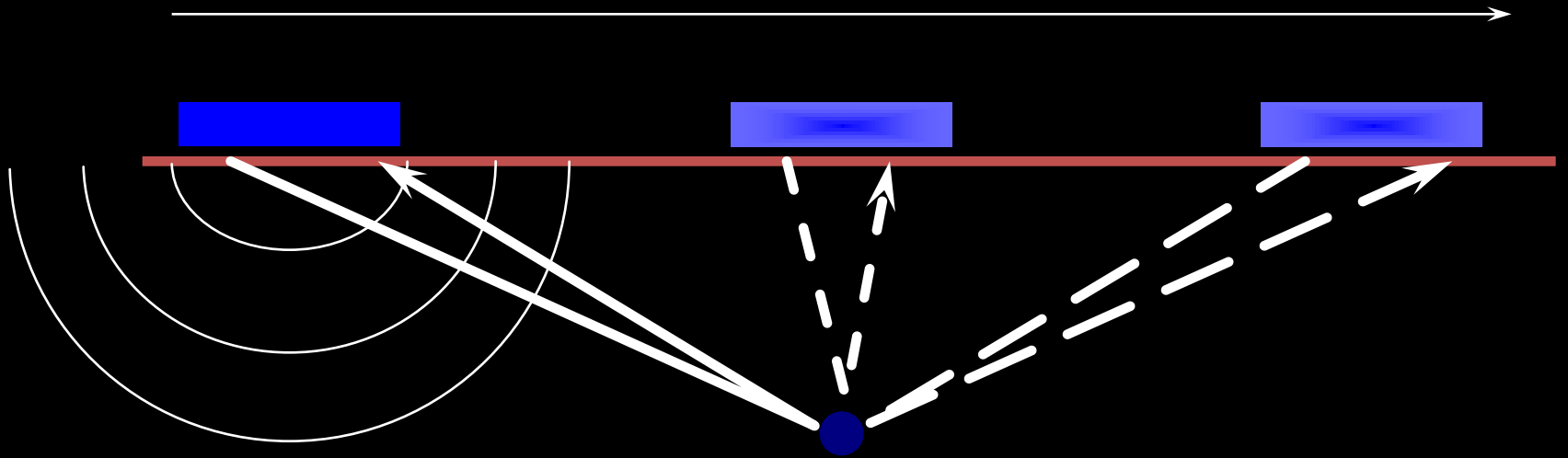
# GSSI



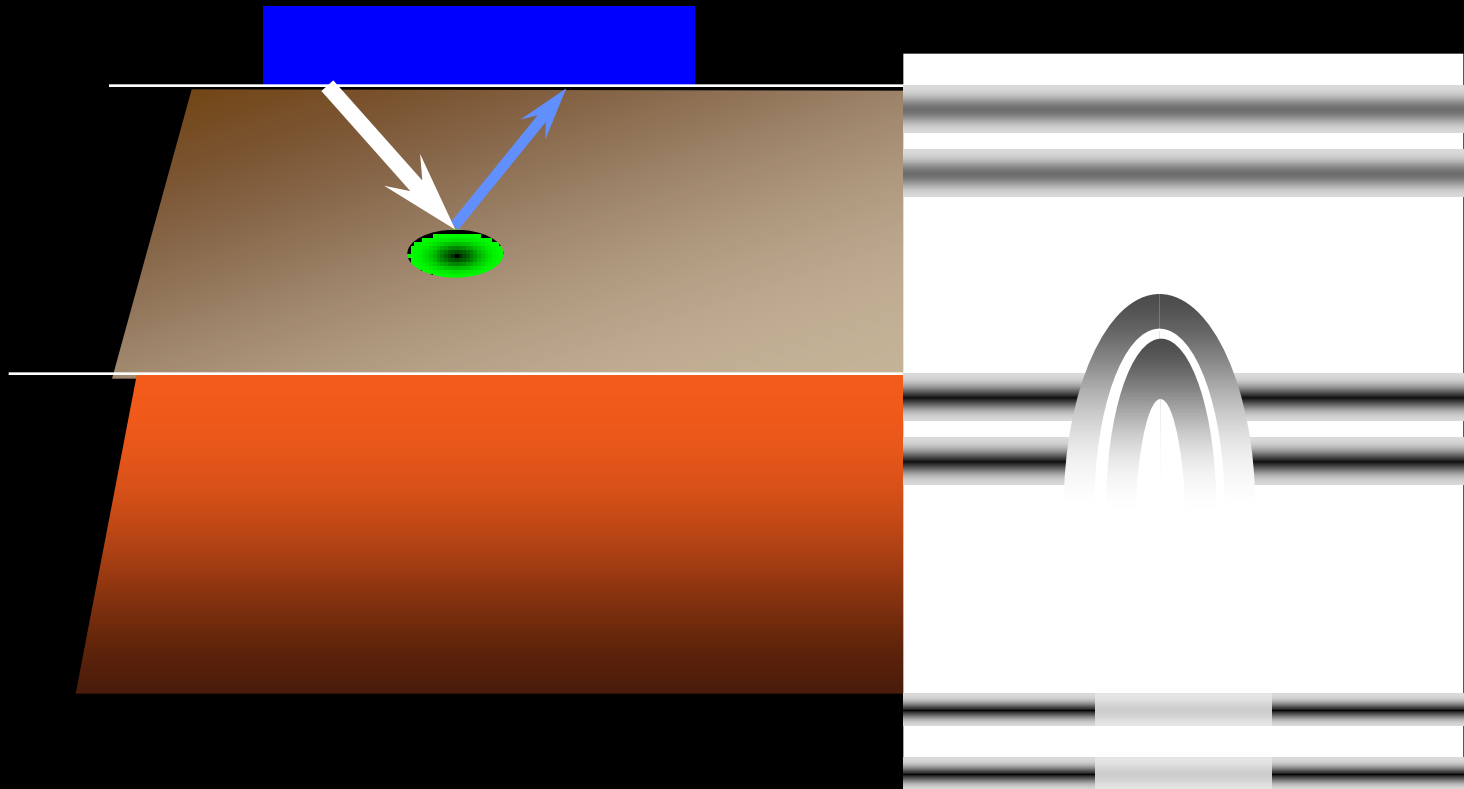
# Radar – in action



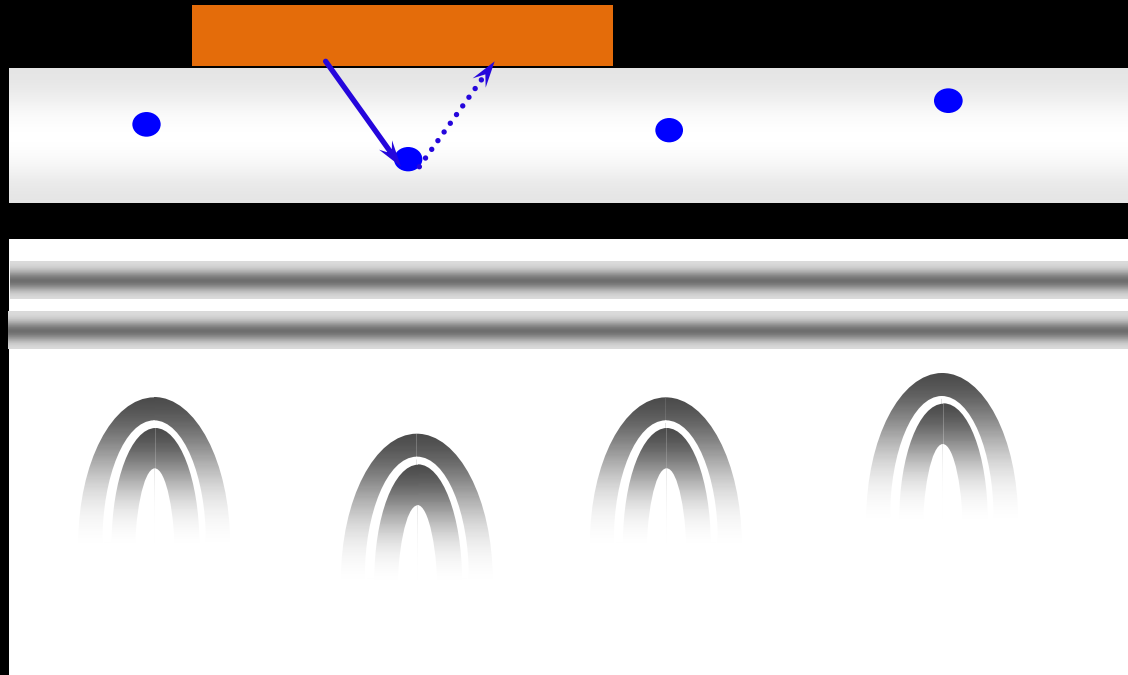
# Hyperbolic Response



# Locating Inclusions

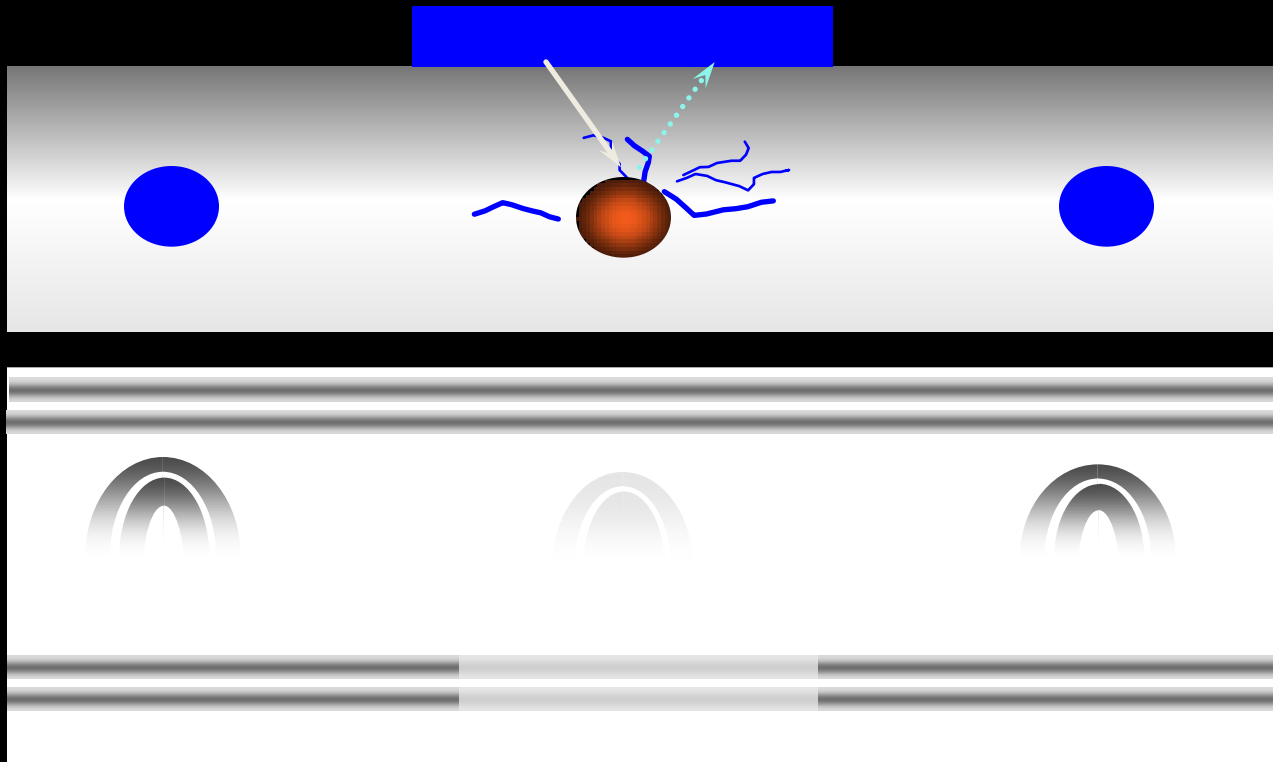


# Hyperbolic Series

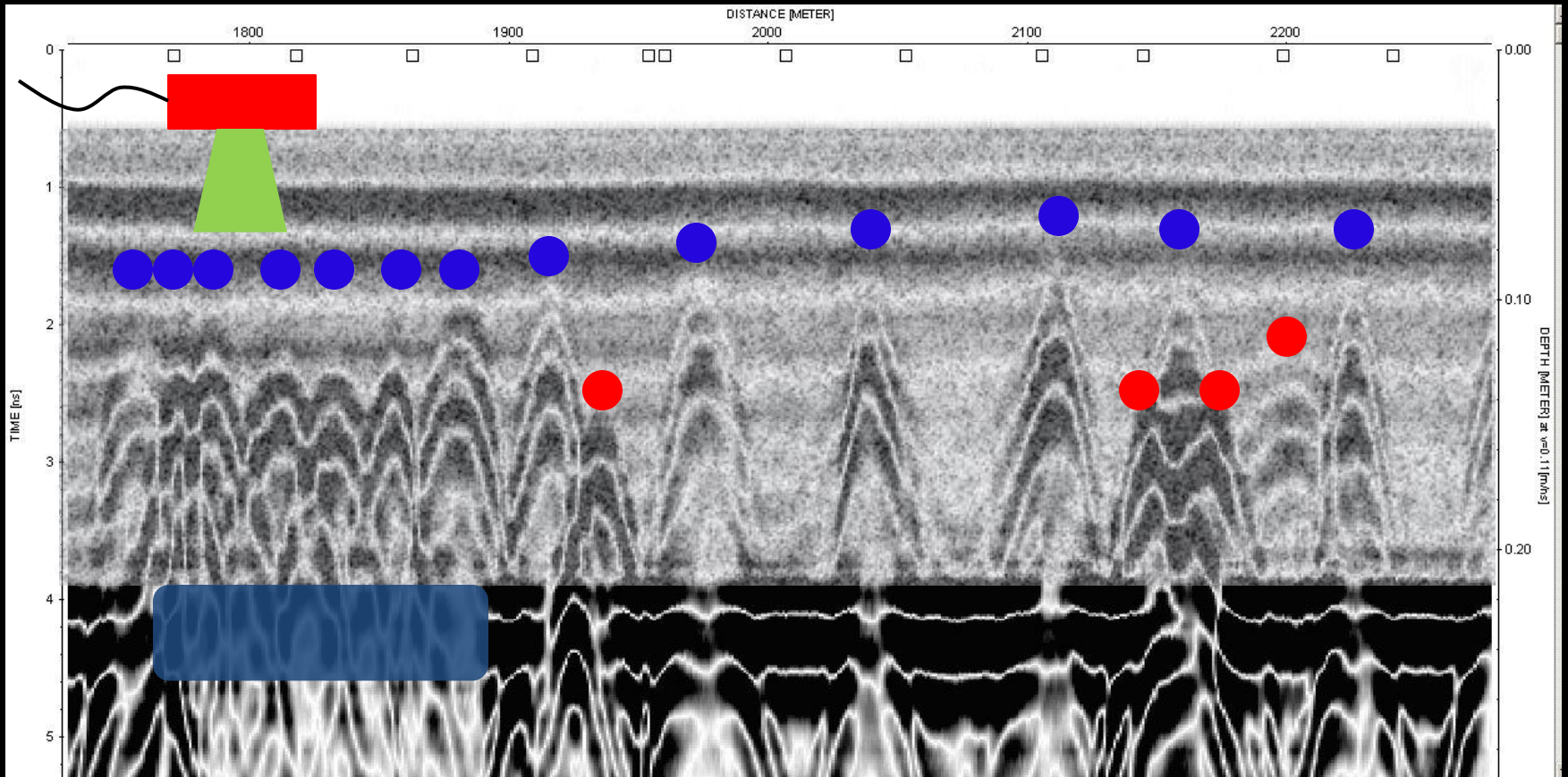




# Condition / Corrosion

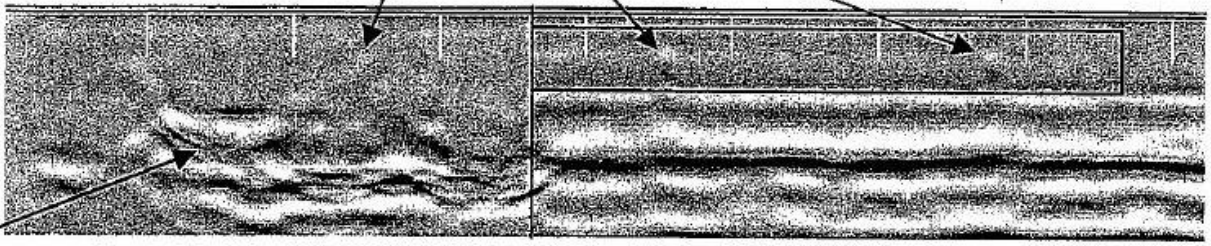


# Data Explanation

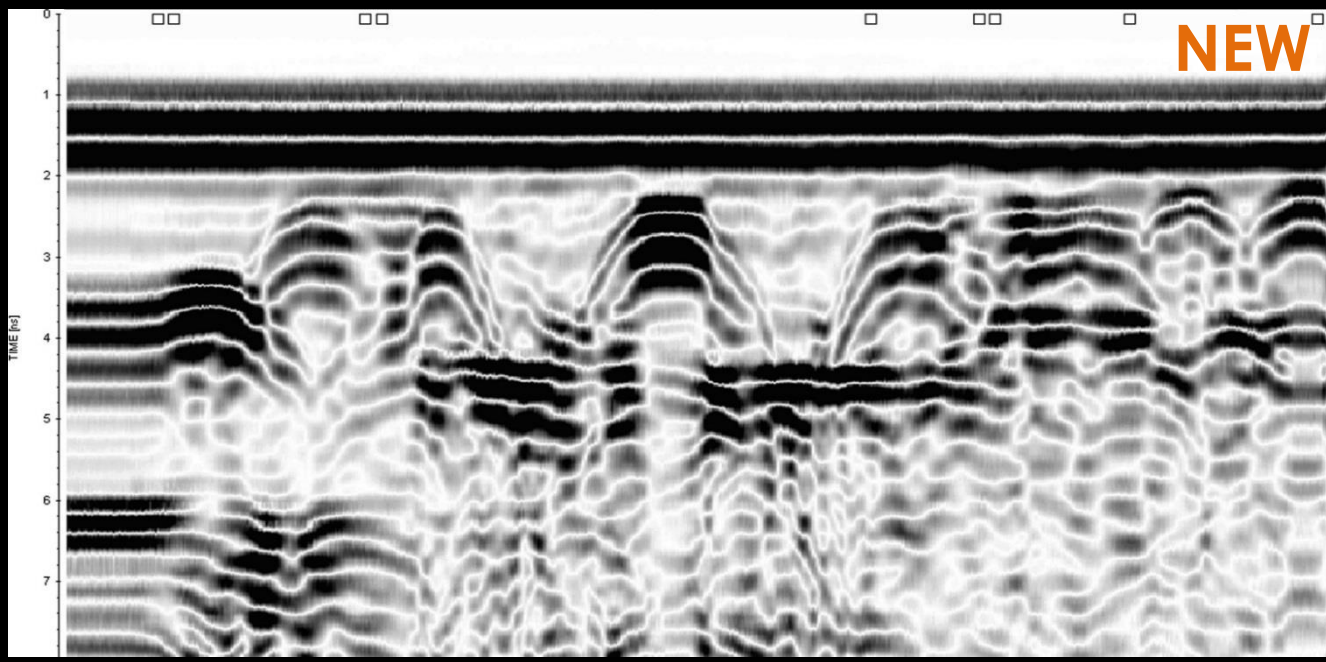


**OLD**

**Pins**



**NEW**



1. INFRARED THERMOGRAPHY

2. GROUND PENETRATING RADAR [GPR]

**3. ACOUSTICS**

4. MAGNETIC METHODS [METAL  
DETECTORS]



# ACOUSTICS

## OVERVIEW

**ACOUSTICAL TESTING IS THE PROCESS  
OF UNDERSTANDING THE  
CONSTRUCTION AND CONDITION OF  
A STRUCTURE BY ANALYZING THE  
BEHAVIOR OF SOUND WAVES**



# ACOUSTICS

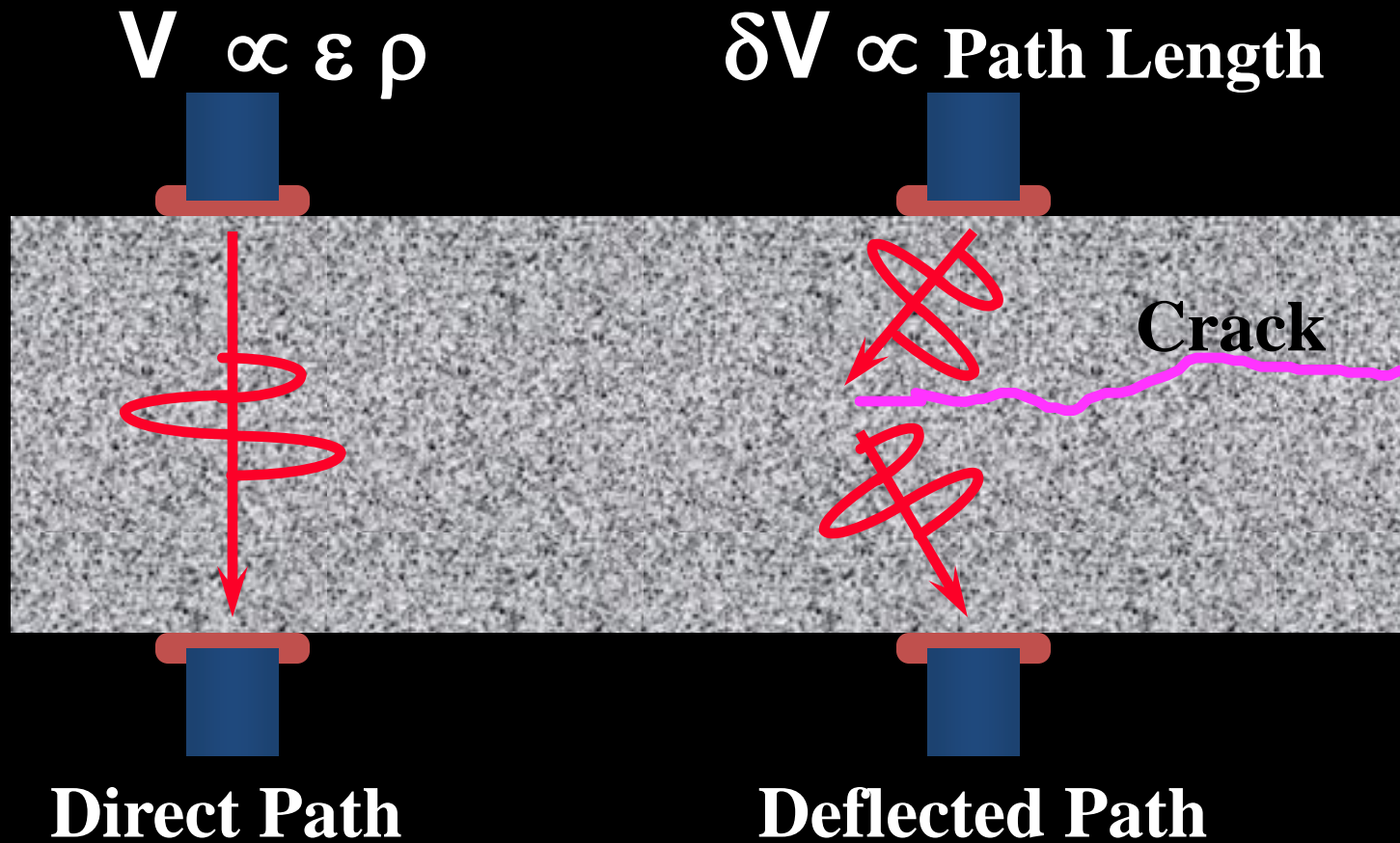
COLLECTION



# Ultrasonics

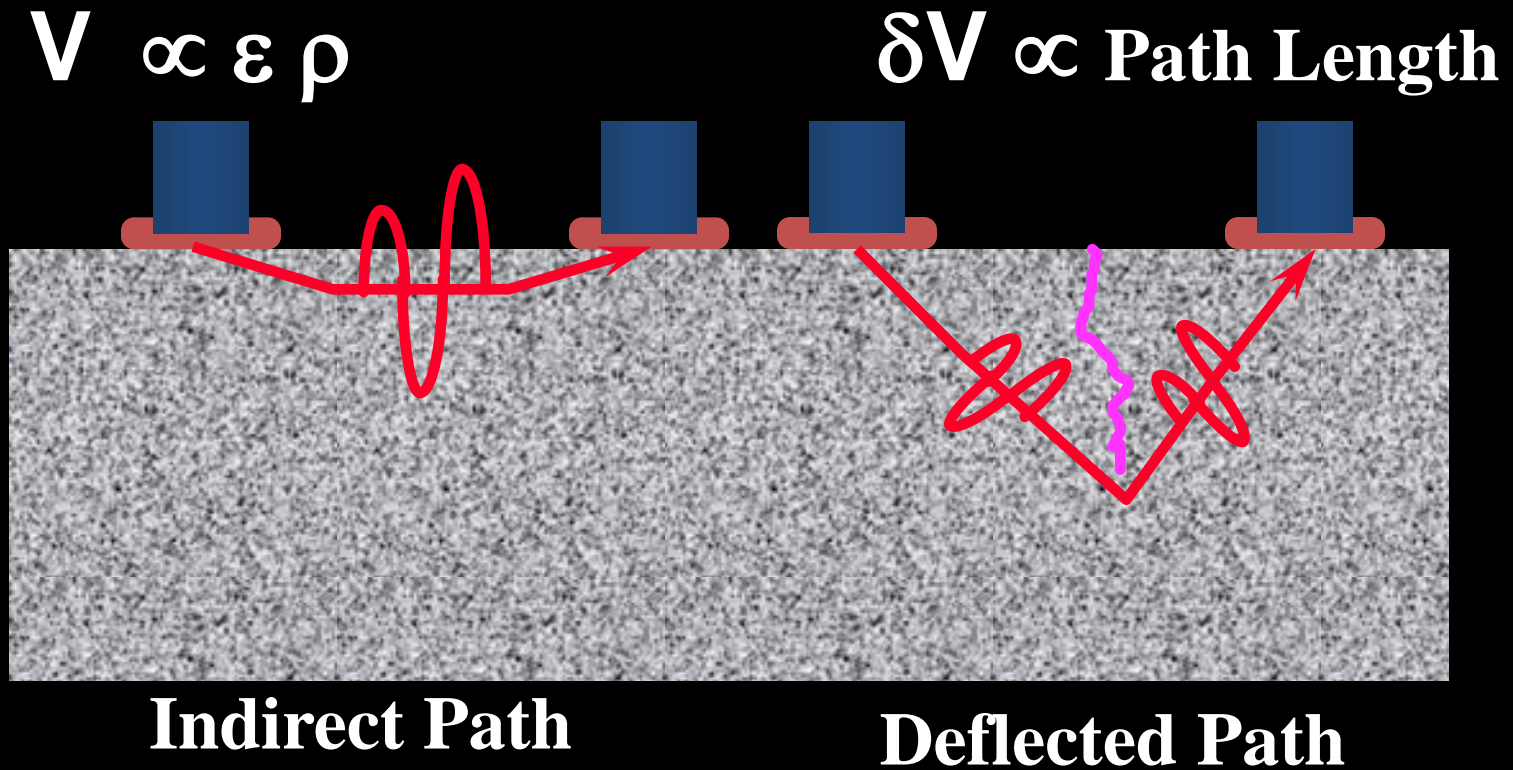
- **Assessment of Elastic Properties**
  - **Relative Strength**
    - **Integrity**
  - **Crack Location**

# Ultrasonics - Through -Transmission



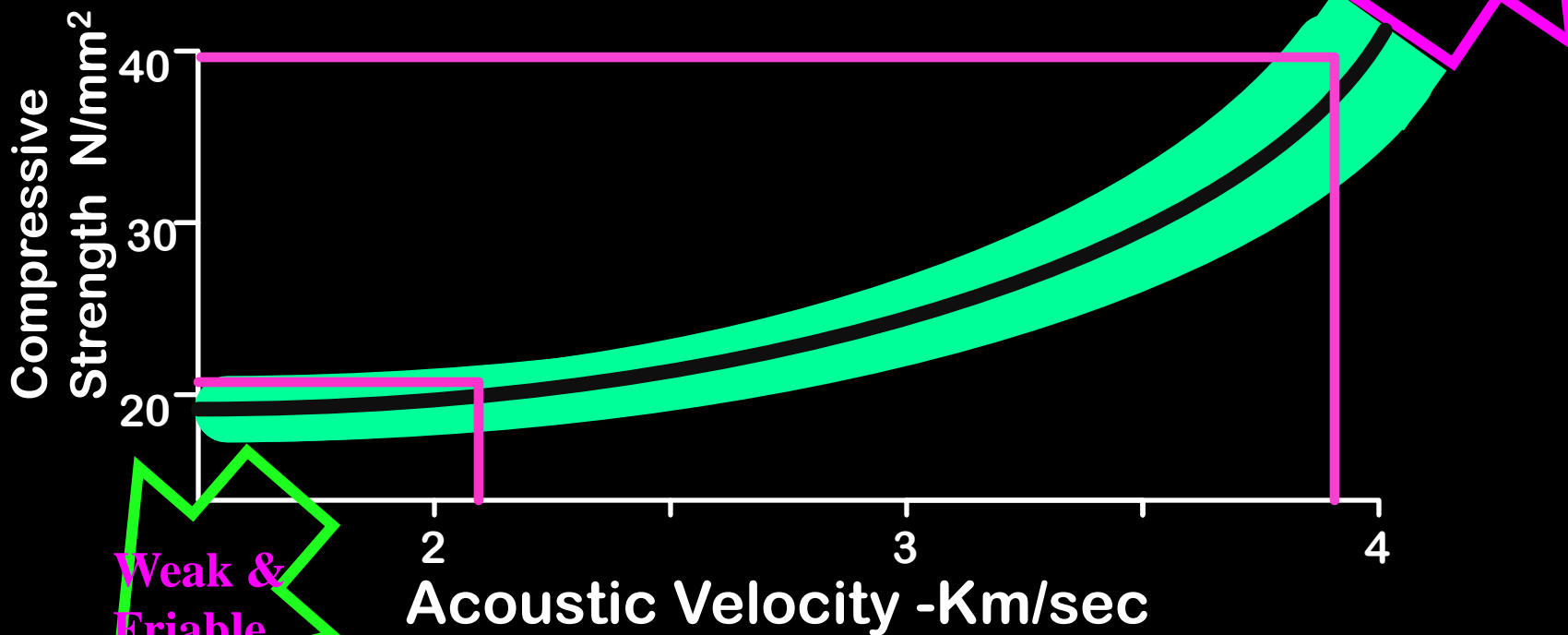


# Ultrasonics - Surface Transmission



# Ultrasonic Assessment

$$V \propto \epsilon \rho$$



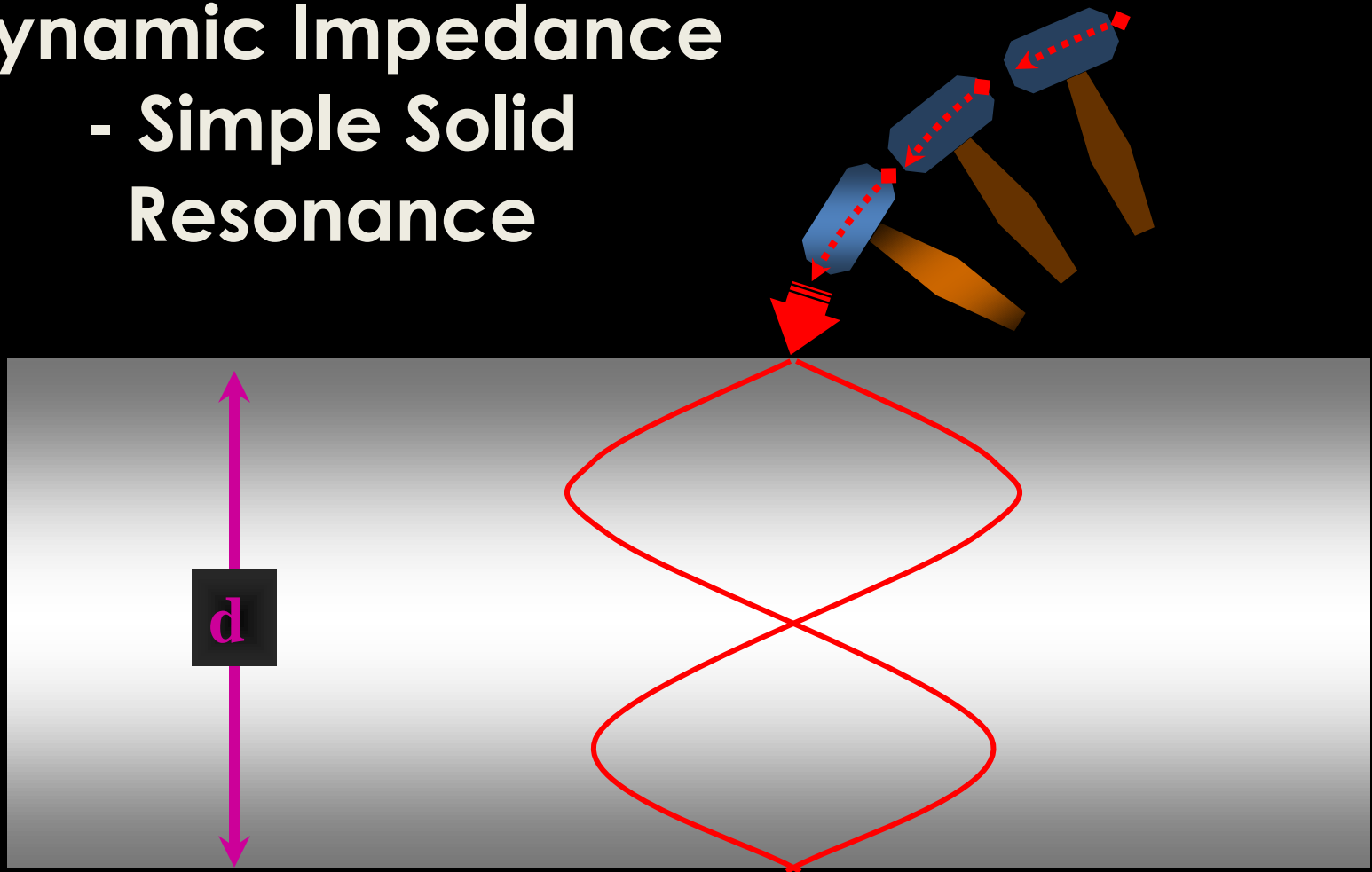
# Acoustic - Dynamic Impedance



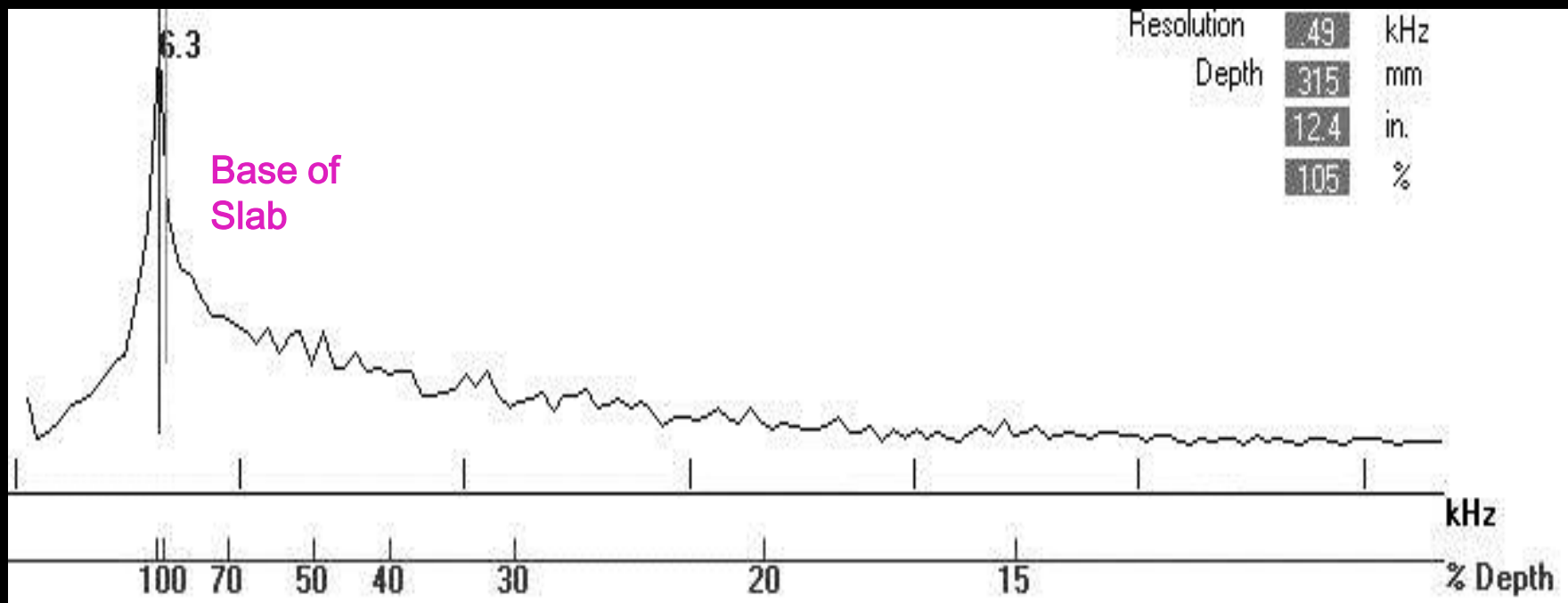


# Dynamic Impedance

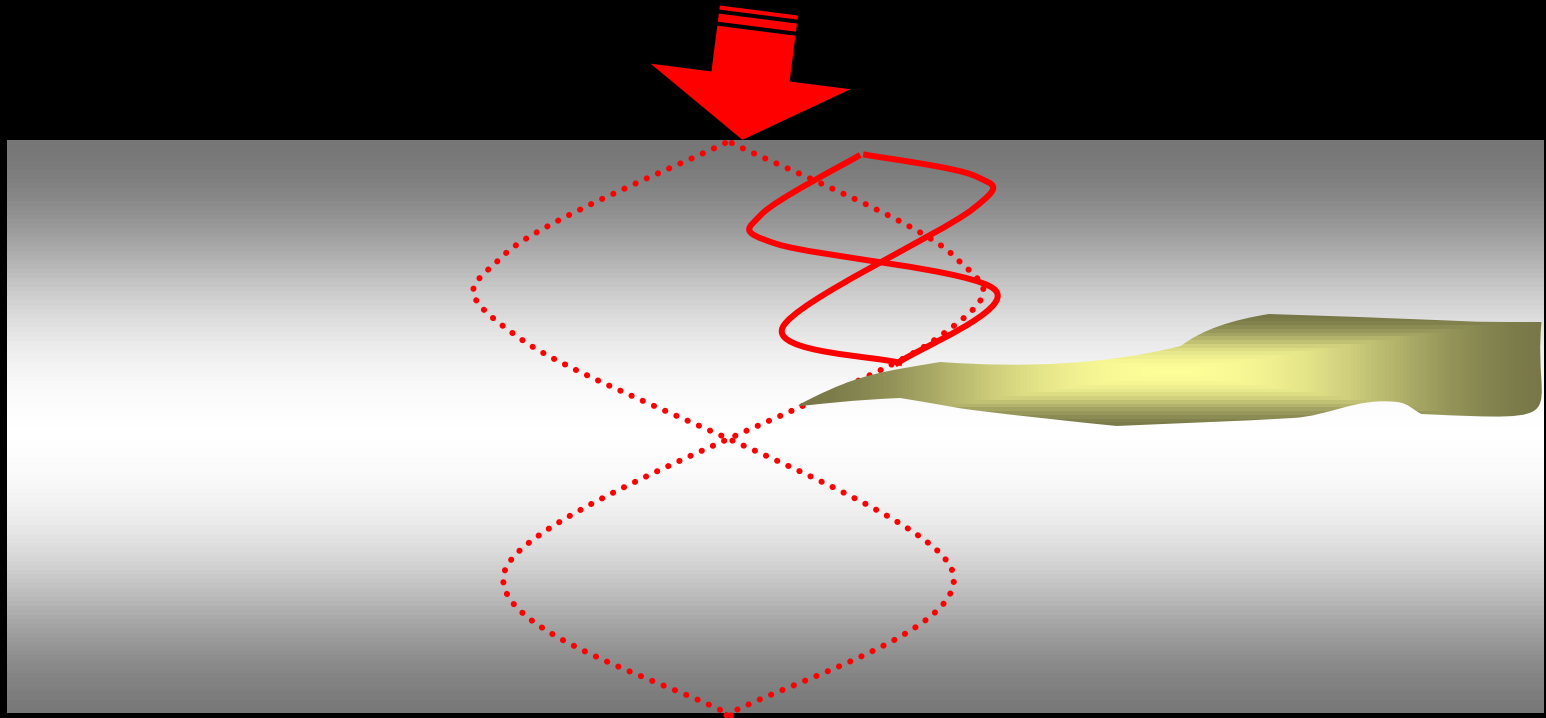
## - Simple Solid Resonance



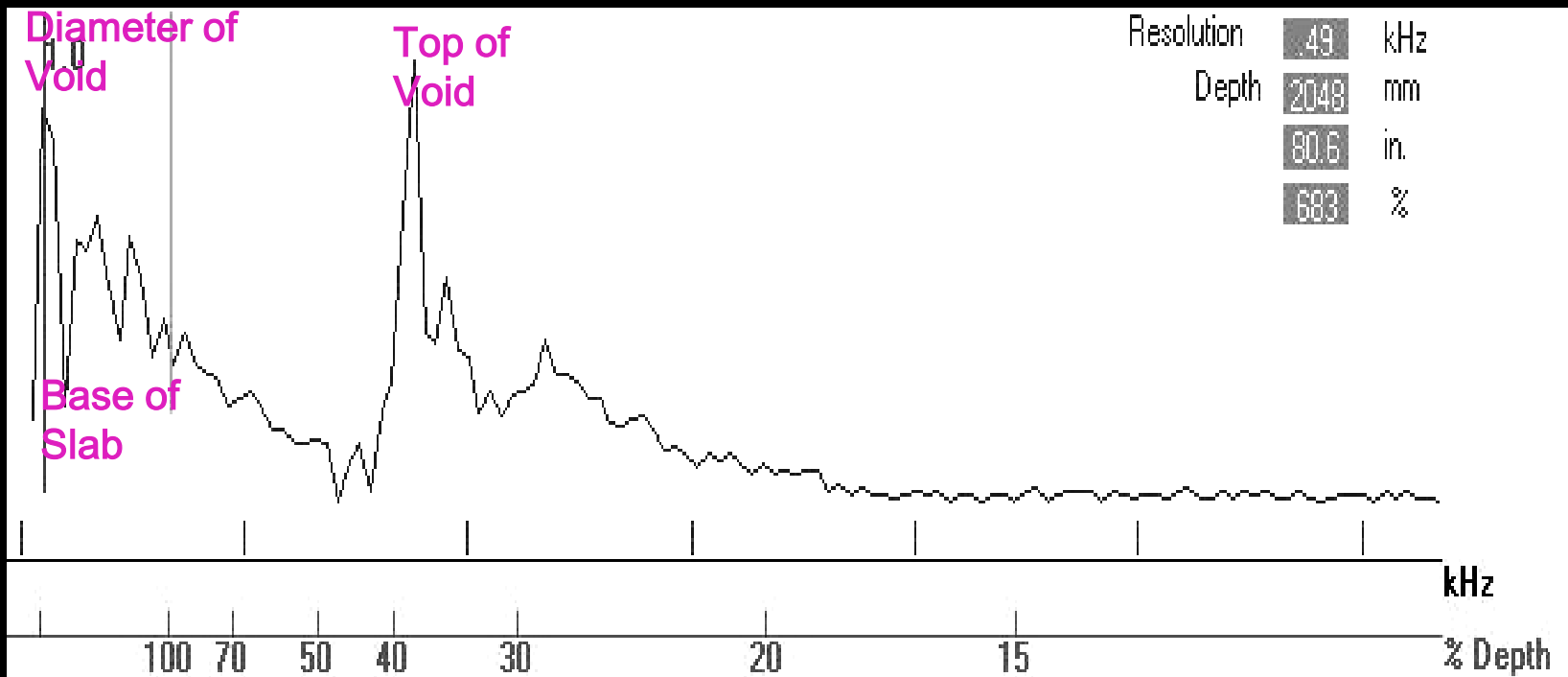
# Simple Slab Resonance - Frequency Domain



# Dynamic Impedance – Solid & Discontinuity Resonance



# Individual Resonances – Cover Concrete + Void Diaphragm





# MAGNETIC METHODS

## OVERVIEW

**MAGNETIC METHODS ARE  
GENERALLY USED TO CONFIRM THE  
PRESENCE OF FERROUS MATERIALS  
WITHIN A STRUCTURE**





**COMMON THEME?**

**INTERPRETATION...**

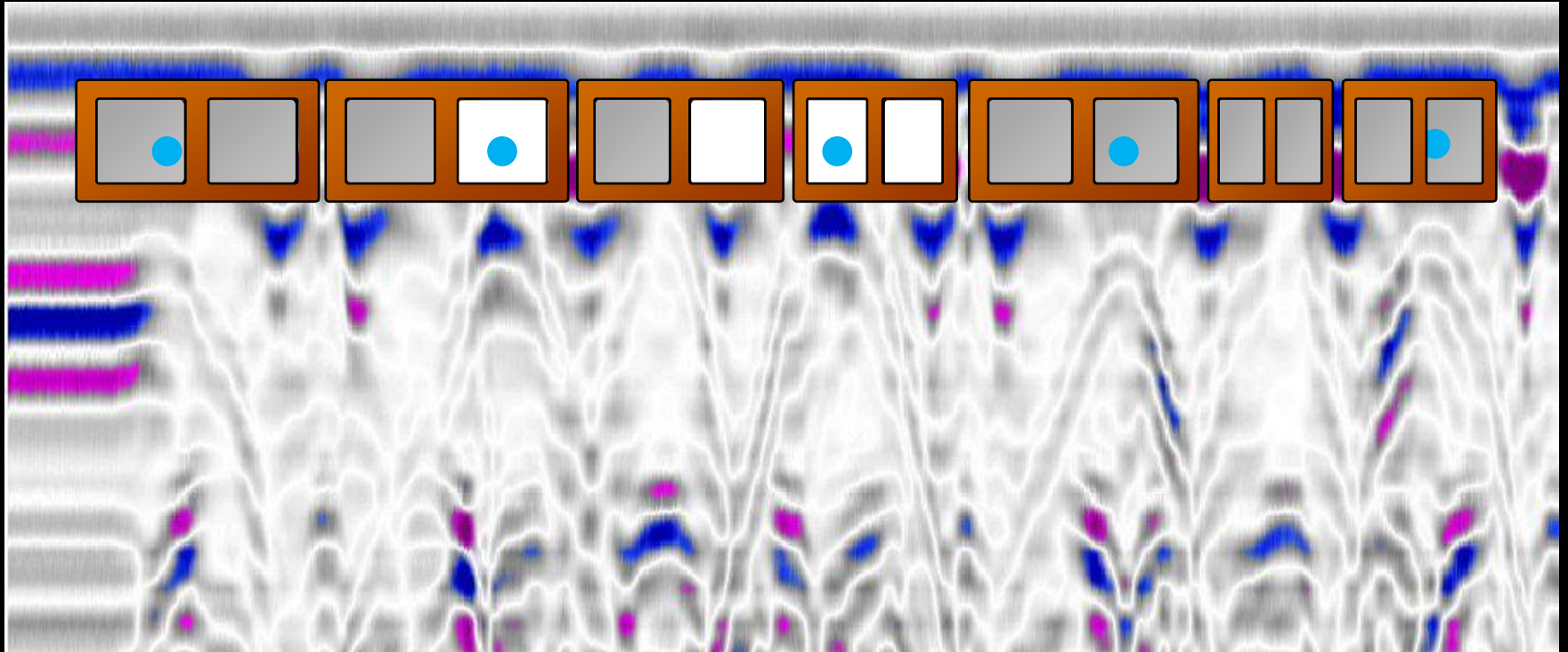


**BASIC...**





# COMPLEX...



**WHY IS INVESTIGATION, INTERPRETATION &  
DOCUMENTATION CRITICAL TO A PROJECT?**

**AND HOW IS IT USEFUL FOR TALL BUILDINGS?**



# VISUAL INSPECTION HAS LIMITS?

ESTABLISHING A BASELINE

**WHAT IS CAUSING THE VISIBLE DAMAGE**

**SOUNDING IS SUBJECTIVE**

**METAL DETECTION PROVIDES SOME ANSWERS**

**IS THERE A PATTERN TO THE DAMAGE**

**WHAT IS HAPPENING BEYOND THE SURFACE**





# WHAT'S WRONG WITH PROBING?

ESTABLISHING A BASELINE

**TALL BUILDINGS MAKE IT DIFFICULT,  
DANGEROUS AND COSTLY**

**RANDOM PROBES MISS VITAL  
CONDITIONS**

**DAMAGE (STRUCTURAL / UTILITIES)**

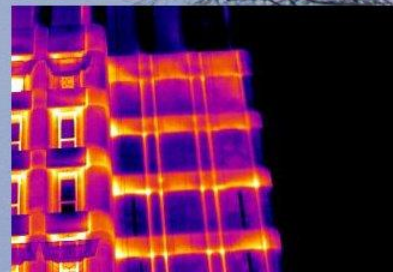
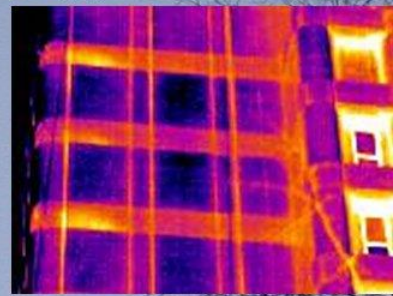
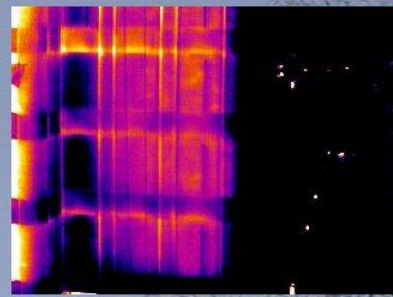
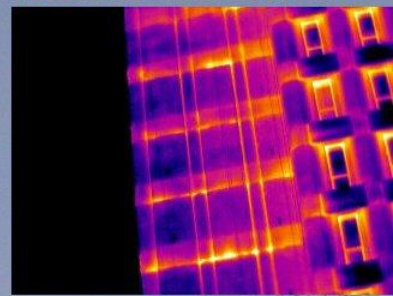
**DISRUPTION TO OCCUPANTS**



SO HOW DO WE USE NDE ON TALL BUILDINGS?



Kline Biology Tower  
Yale University,  
New Haven





# **BIG** SCALE PROBLEMS



# **PROBLEMS OF EMBEDDED STEEL CORROSION**

**PERFECT FOR NDE**

**DIFFICULT ACCESS**



ACCESS





**FAITH IN  
INGENUITY**

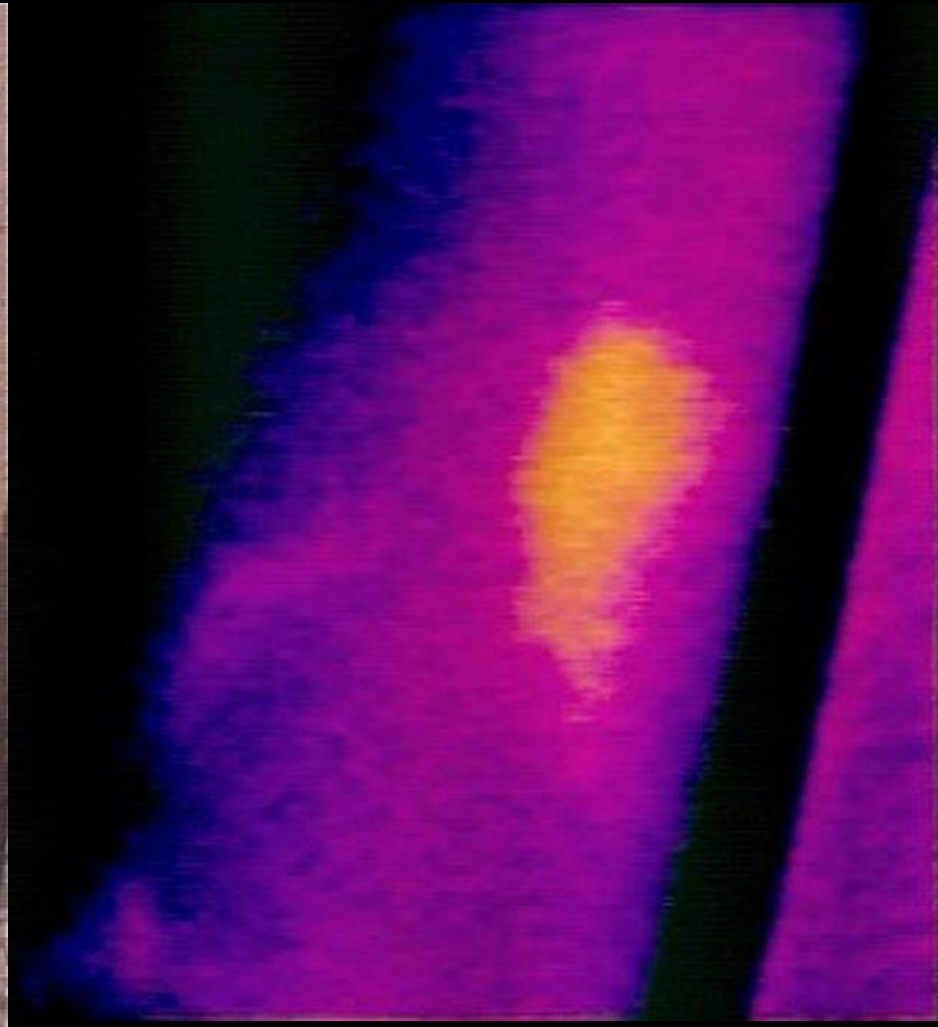


**COLD!!!!**

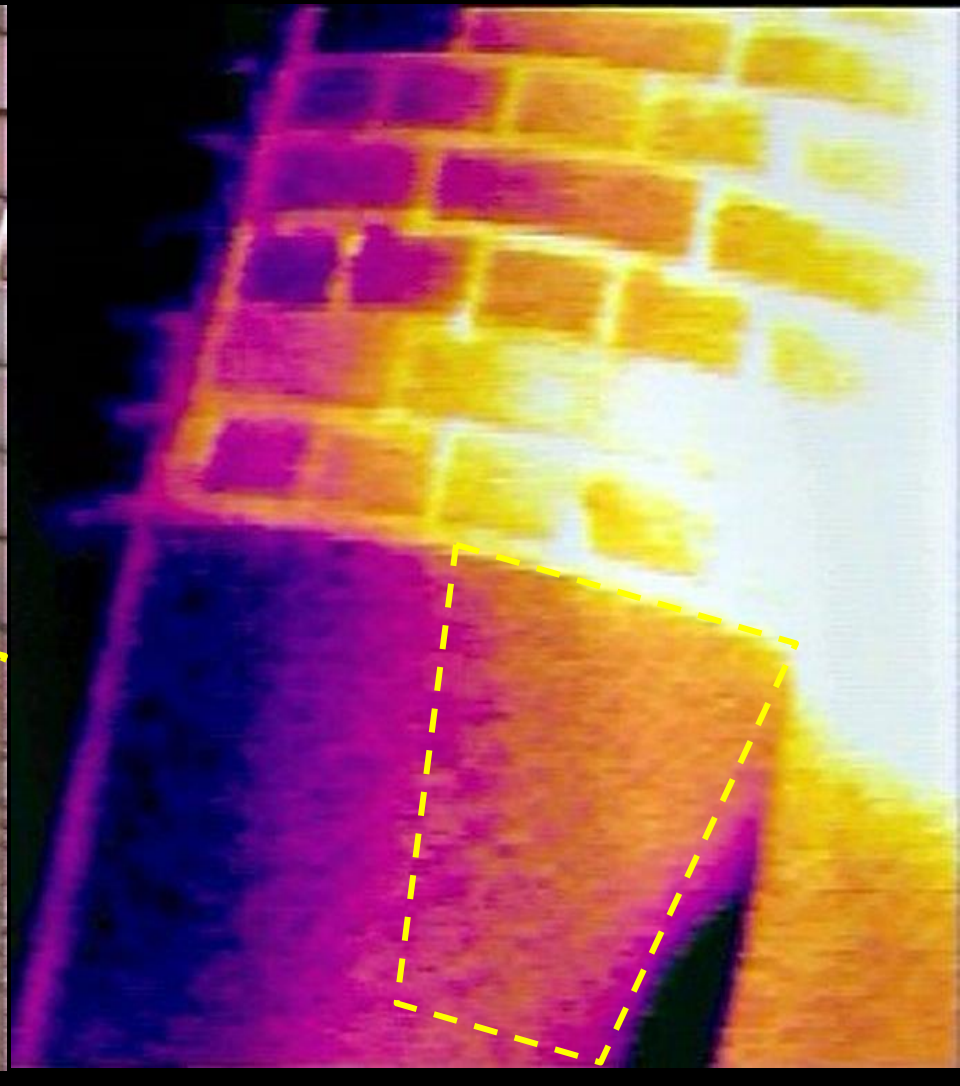
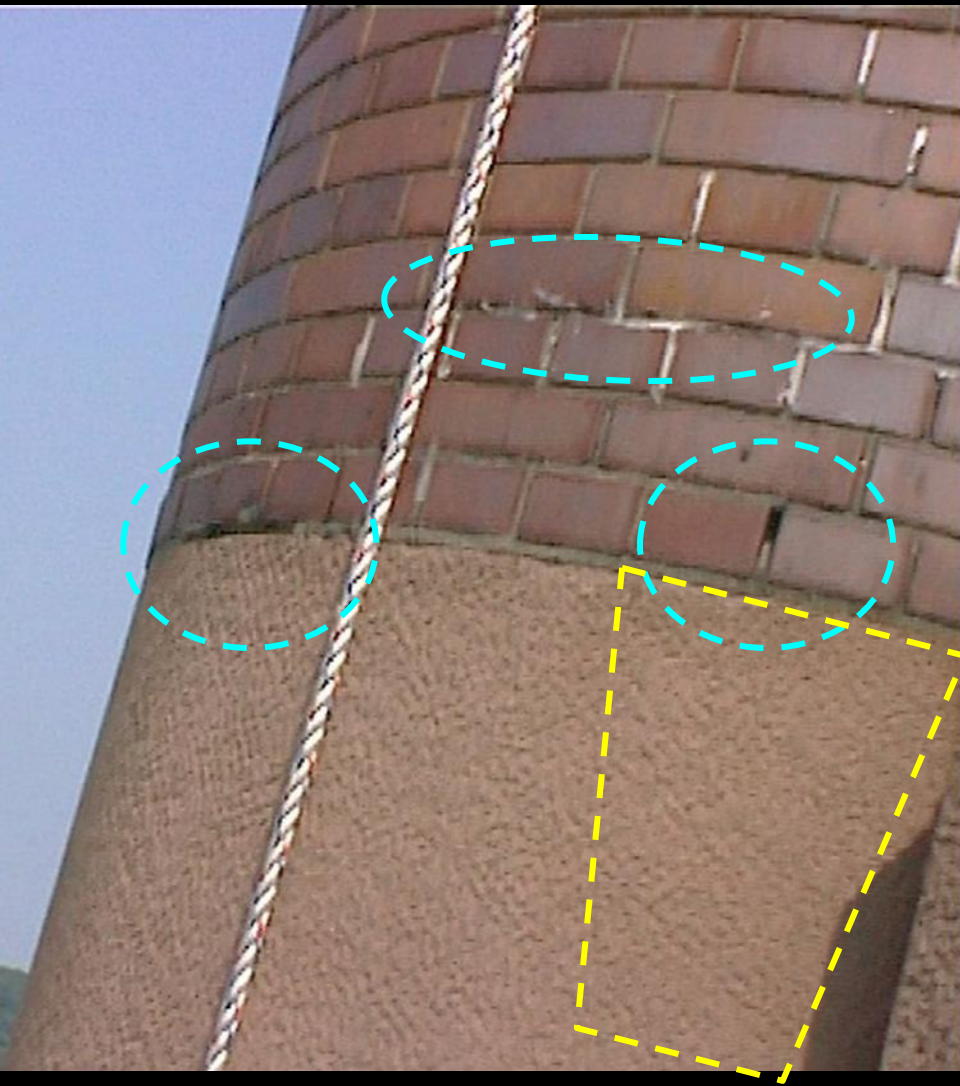




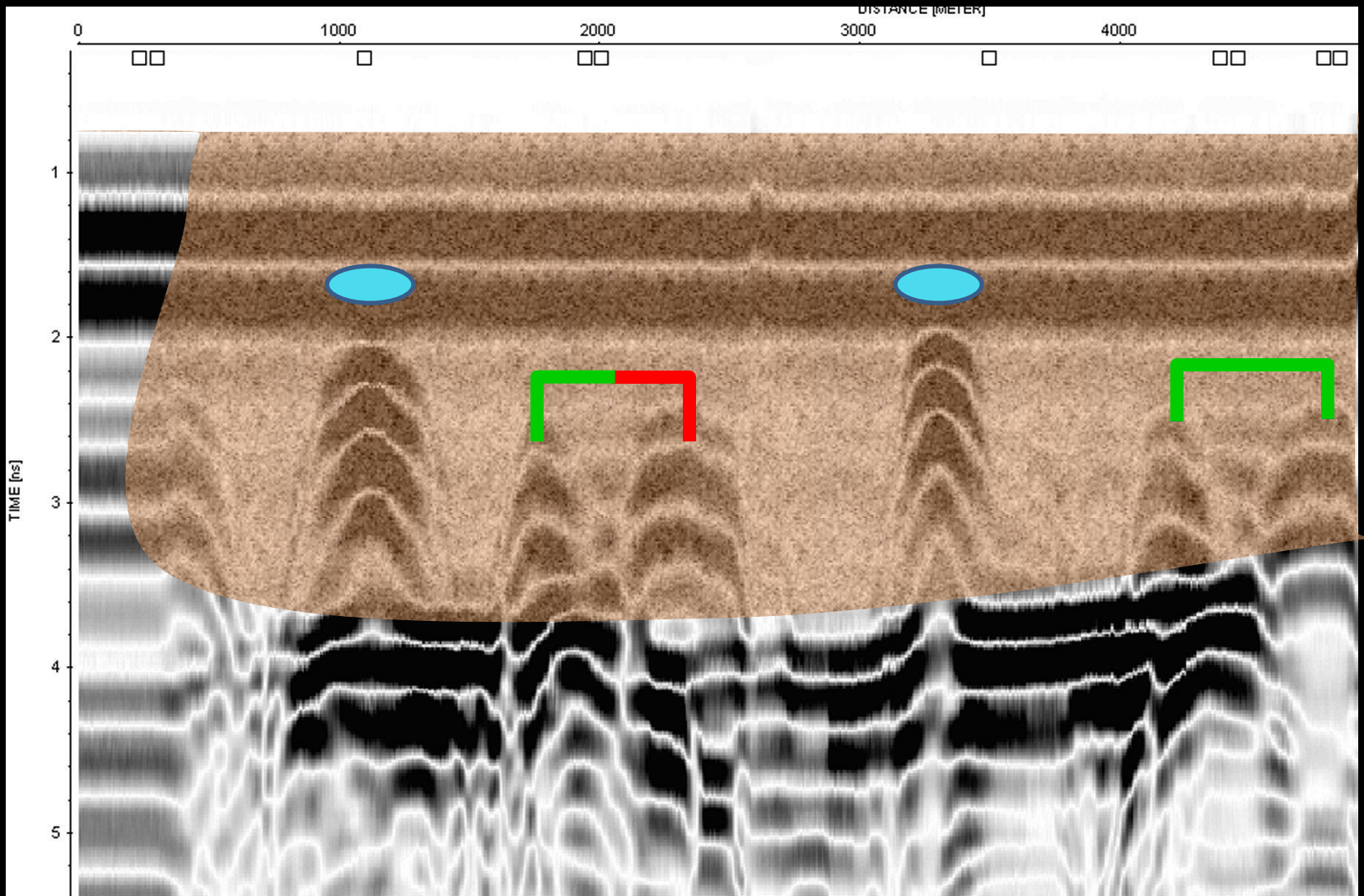
# THERMAL IMAGING



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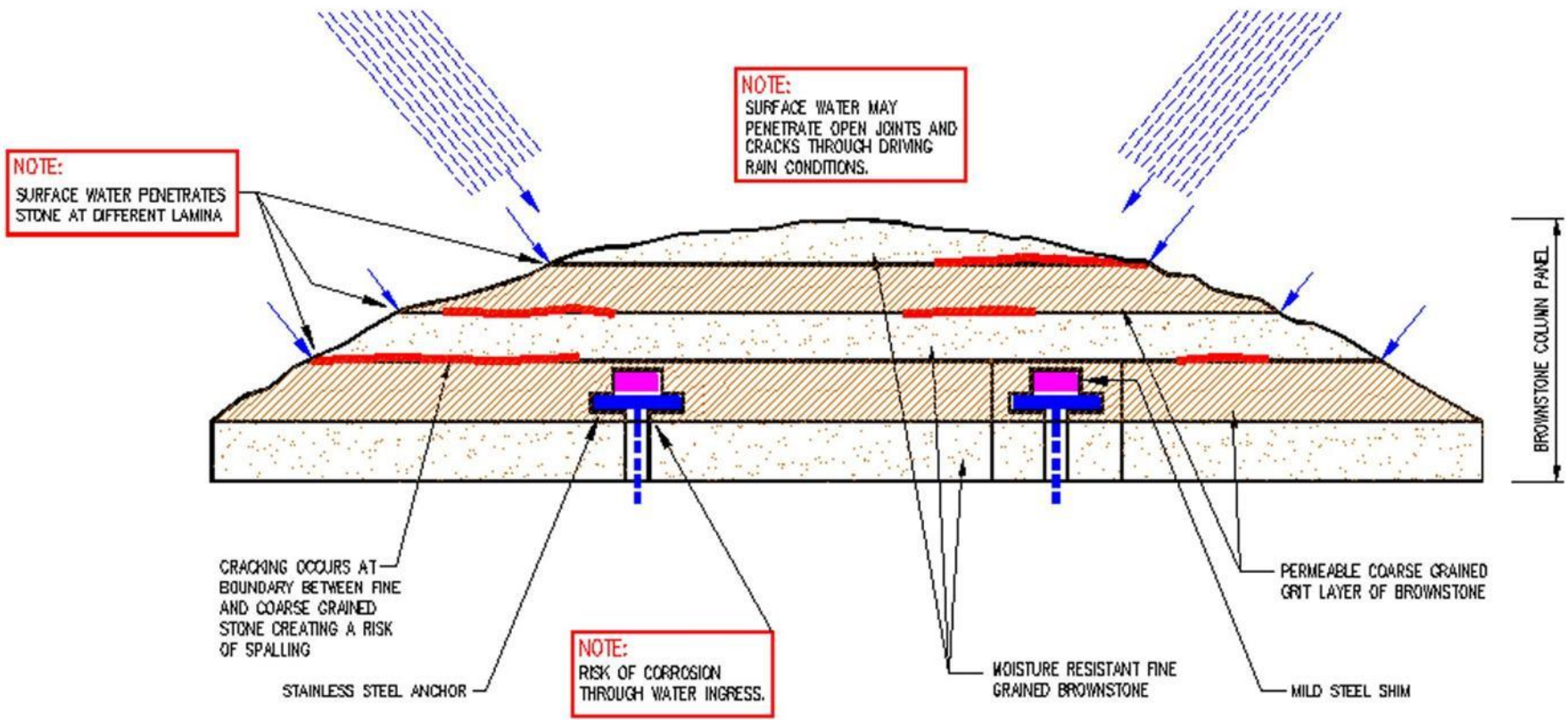


# Radar and Metal Detection



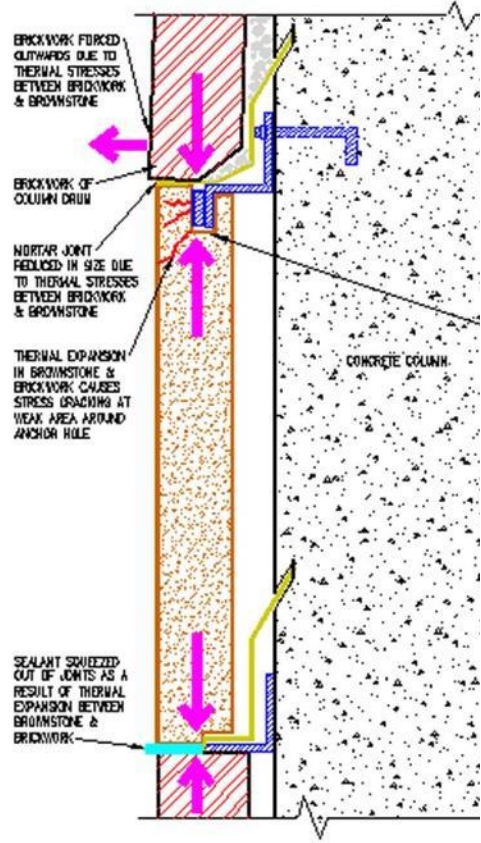
# FINDINGS IN PLAN

GEN.2A: SCHEMATIC SECTIONS THROUGH BROWNSTONE PANEL SHOWING WATER INGRESS AT LAMINA BOUNDARIES RESULTING IN BROWNSTONE EXFOLIATION AND POSSIBLE FUTURE CORROSION OF MILD STEEL SHIMS THROUGH MOISTURE INGRESS

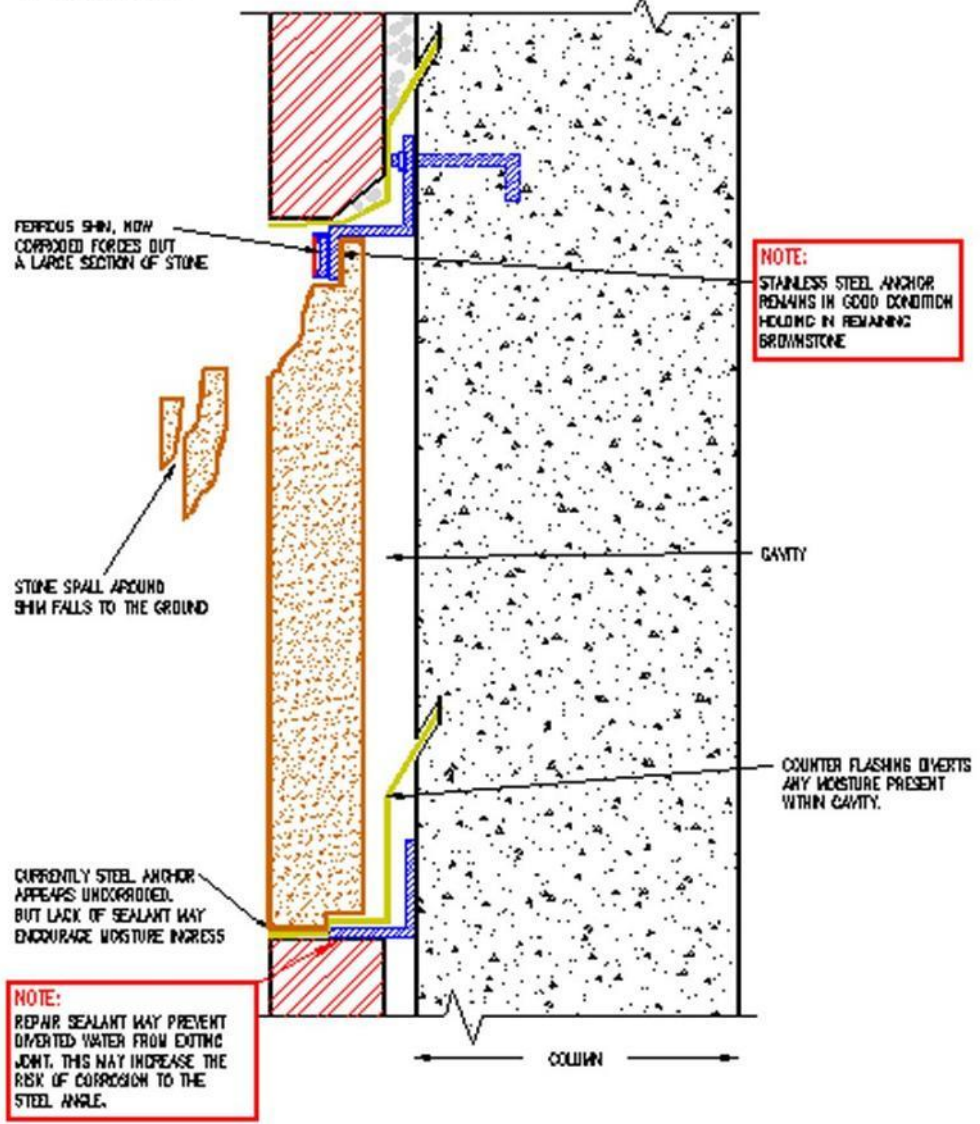


# FINDINGS IN SECTION

GEN.1.C: STEP 2 - SCHEMATIC SECTION SHOWING EFFECTS ON BROWNSTONE



GEN.1.E: STEP 4 - SCHEMATIC SECTION SHOWING CORROSION OF SHIM AND FAILURE OF BROWNSTONE



**SOMETIMES NDE ISN'T SO HI-TECH...**



**CASE STUDY:  
TRACING THE  
SOURCE OF A  
KNOCKING  
NOISE IN A  
LUXURY CONDO  
BUILDING...**



# BUILDING DOCTORS?





**SOUND  
REPLICATED BY  
TAPPING HOT  
WATER RISER IN  
MACHINE ROOM**





**SOUND COMING FROM  
RATTLING CABLES**



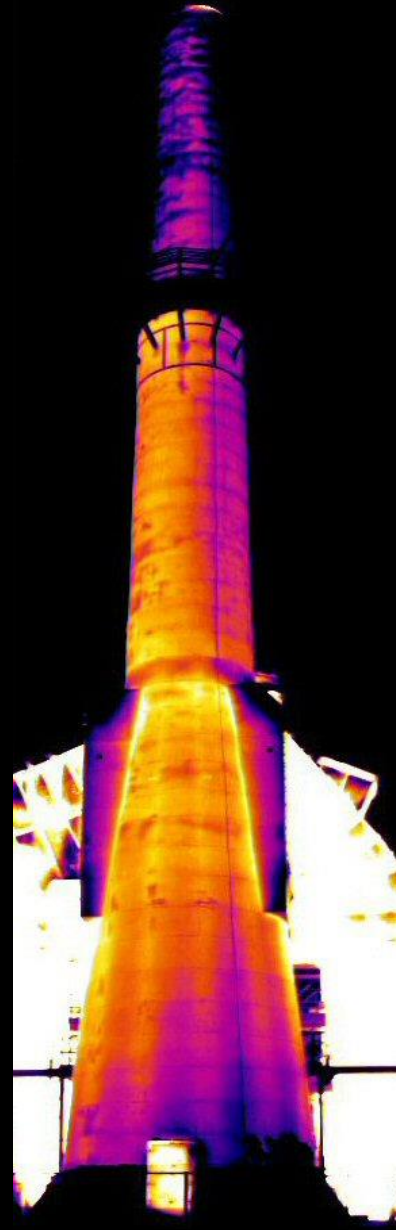
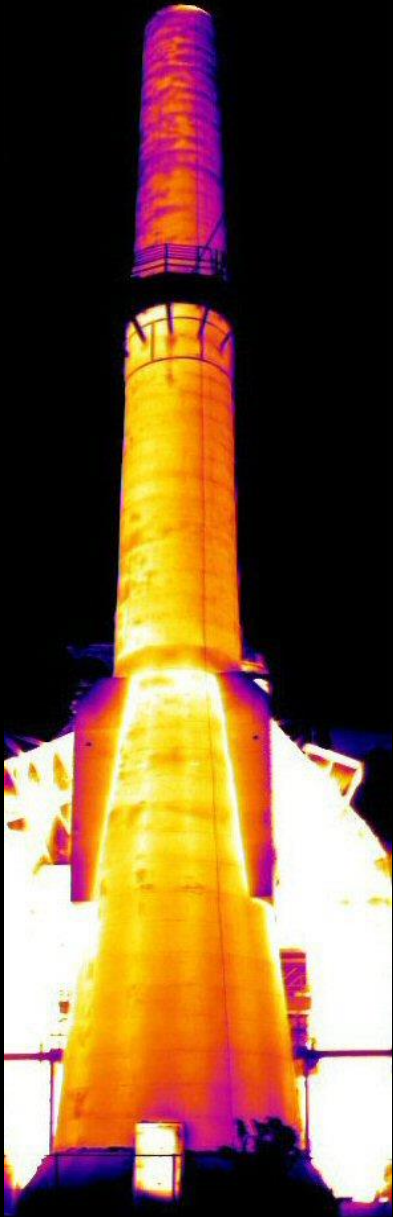
**JUST BECAUSE YOU'RE WORKING ON A TALL  
BUILDING / STRUCTURE IT DOESN'T MEAN YOU  
HAVE TO WORK UP HIGH...**

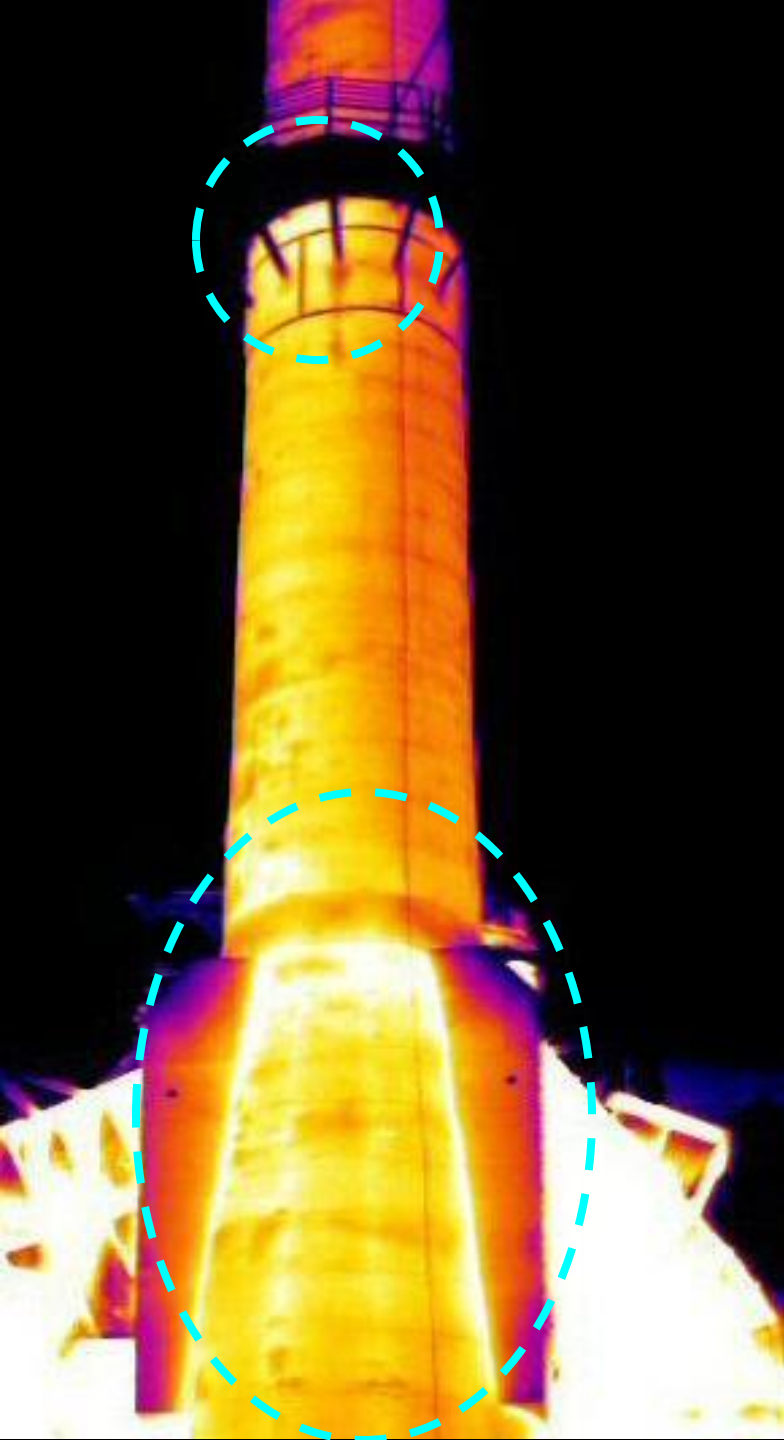


# CASE STUDY: WHYALLA STEEL WORKS



# NEVER HAD TO LEAVE GROUND LEVEL...





# ASSESSMENT OF INNER BRICK LINING ...

**PRODUCTION  
NEVER STOPPED!**



# Documentation / Measured Building Survey (MBS)





# REASONS FOR **MBS**

**New Drawings Required**

**Historical Documentation**

**Project Estimating**

**Structural Monitoring**

**Advertising / Promotion**

**Rapid Response Recording**

# CASE STUDY:

Recladding project  
60 floors up...



# Purpose of Survey

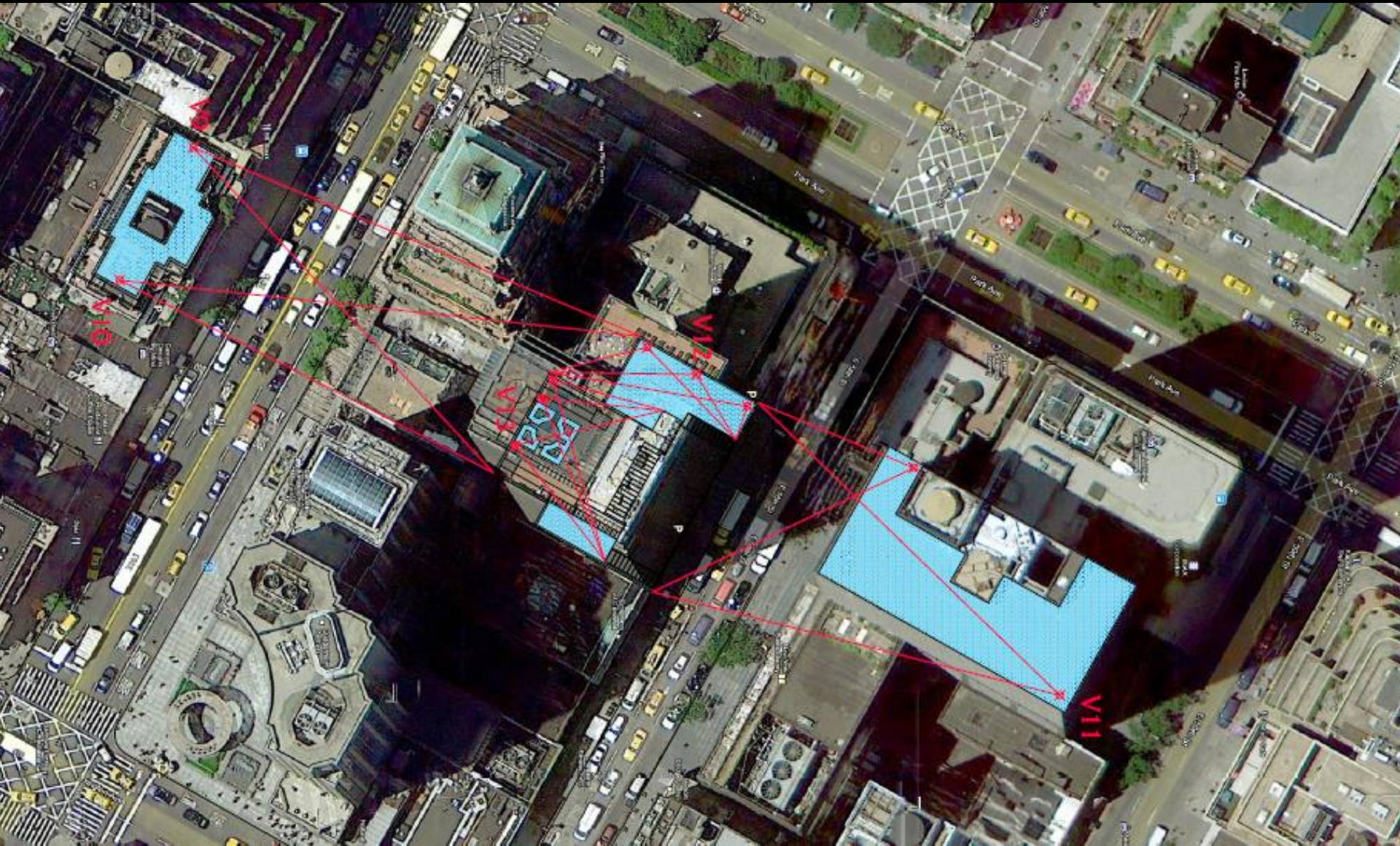
To scan the exterior to **high level of accuracy**

Provide accurate wall square footage for **cladding prefabrication and cost estimating**

Provide drawings and model for **future construction projects**

So how can you scan a 60 storey building  
to a **high level of accuracy** in  
Manhattan?

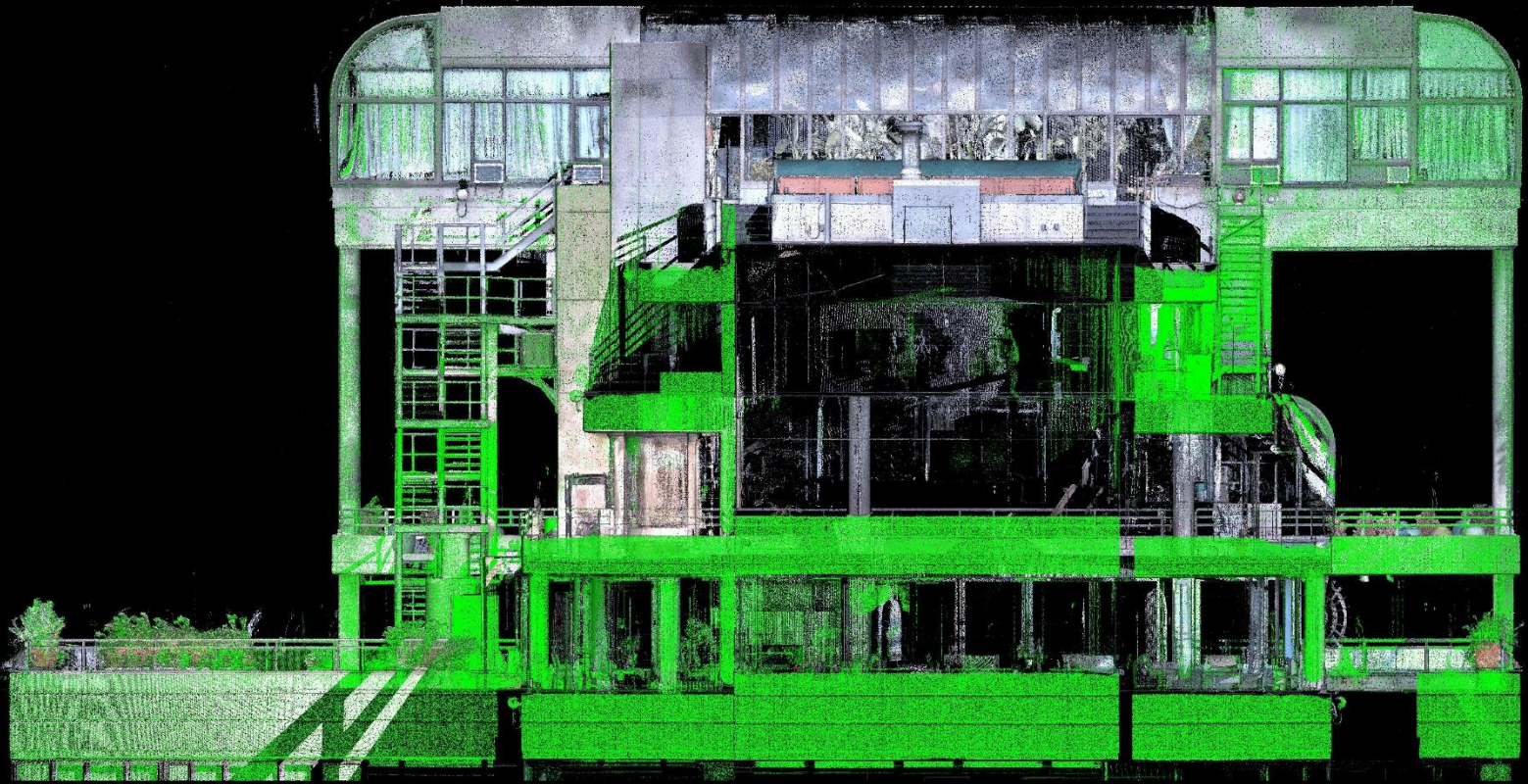
# Vantage Points Refined:



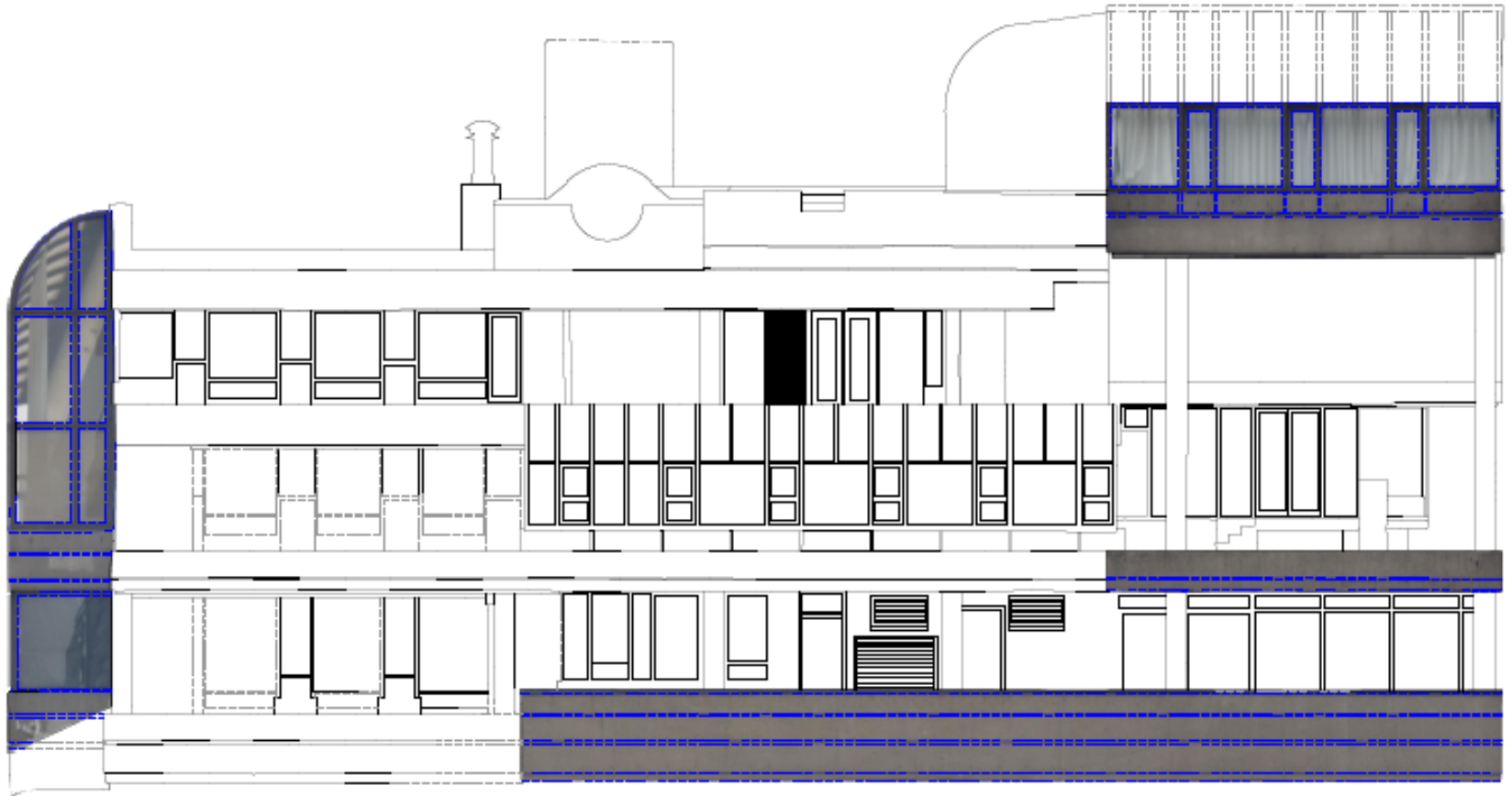
# Scanner positioned at vantage points



# Point Cloud / Elevations Generated



# Drawings / Elevations Processed



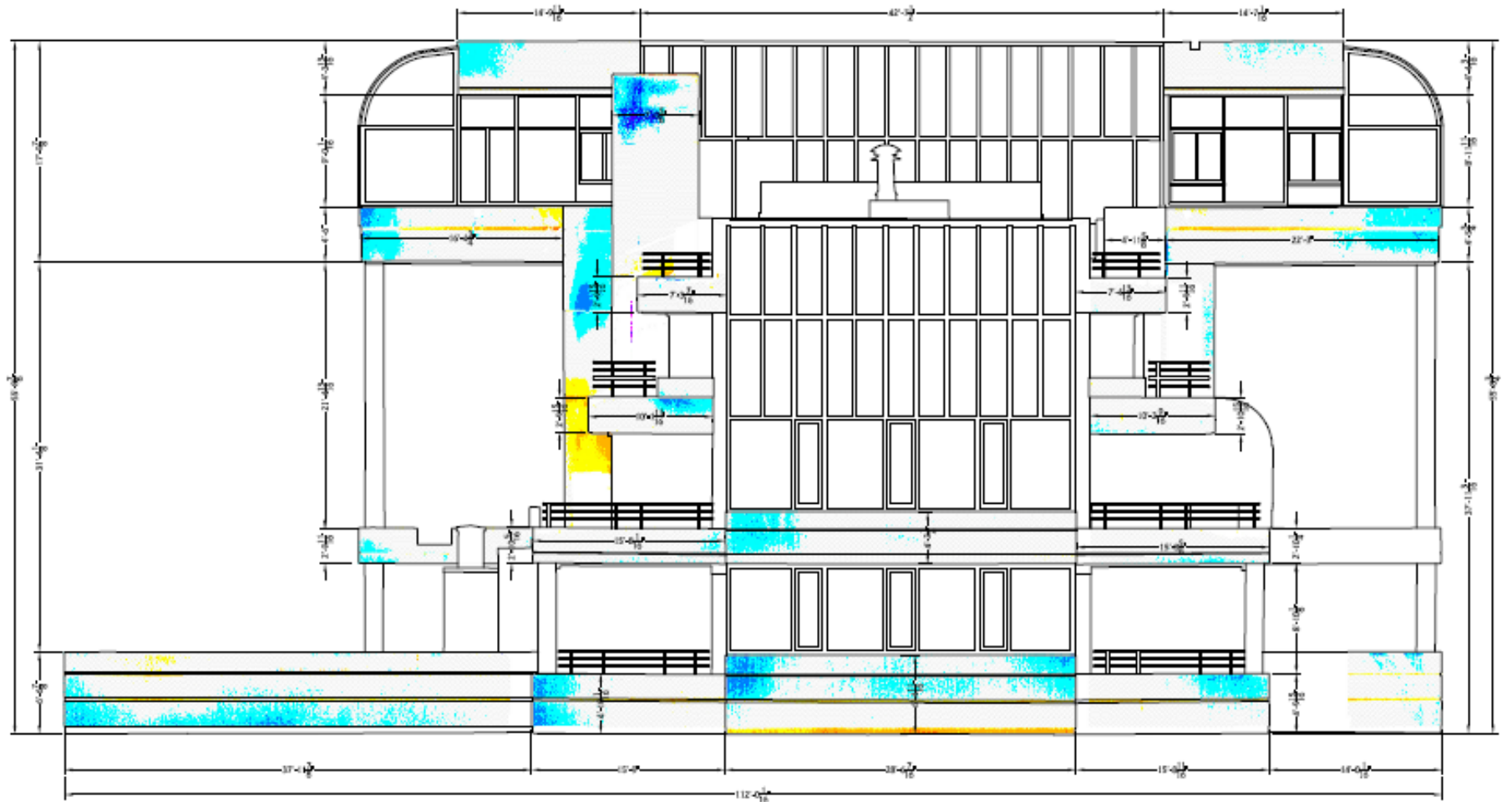
PRELIMINARY



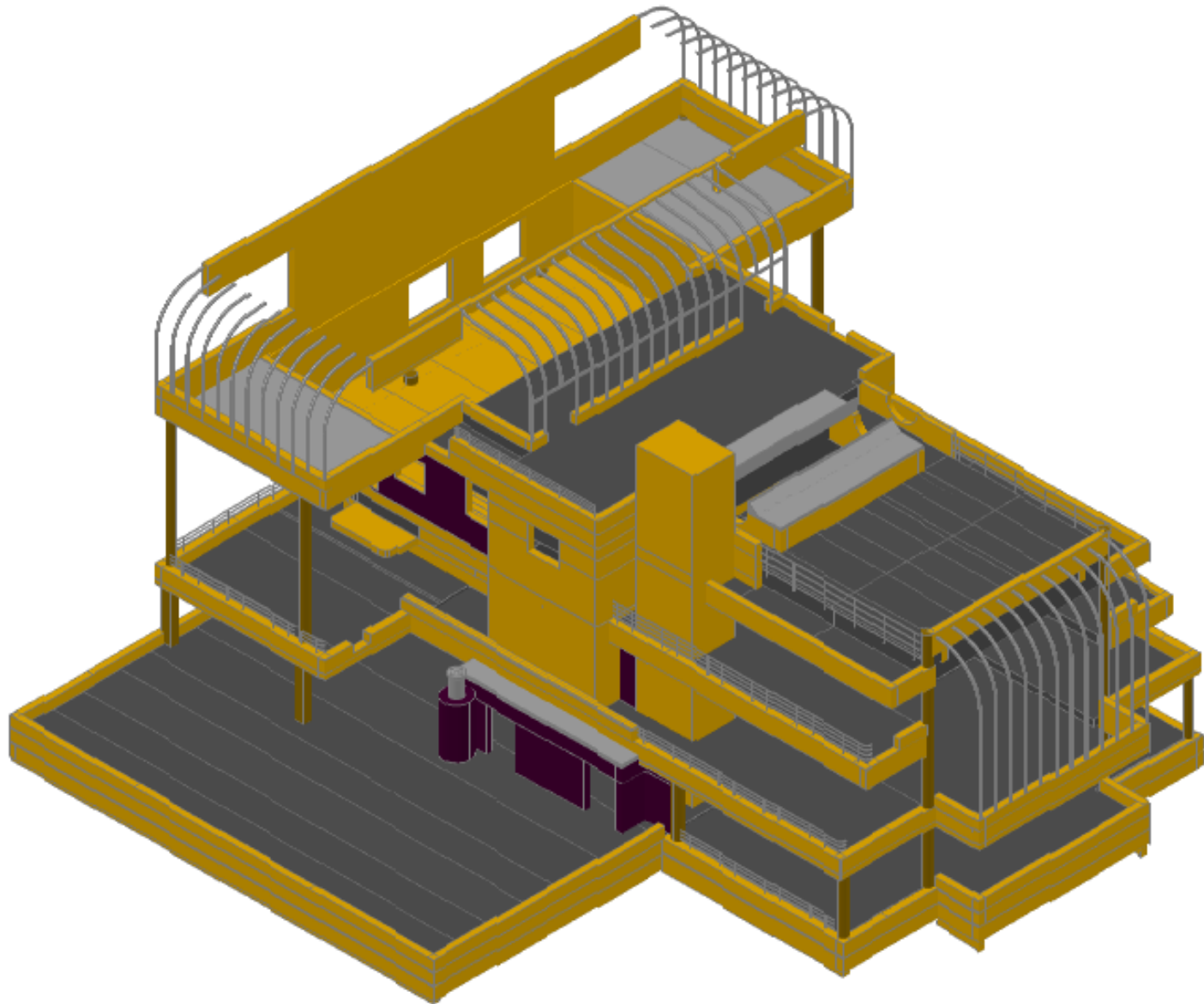


# Now it gets clever...

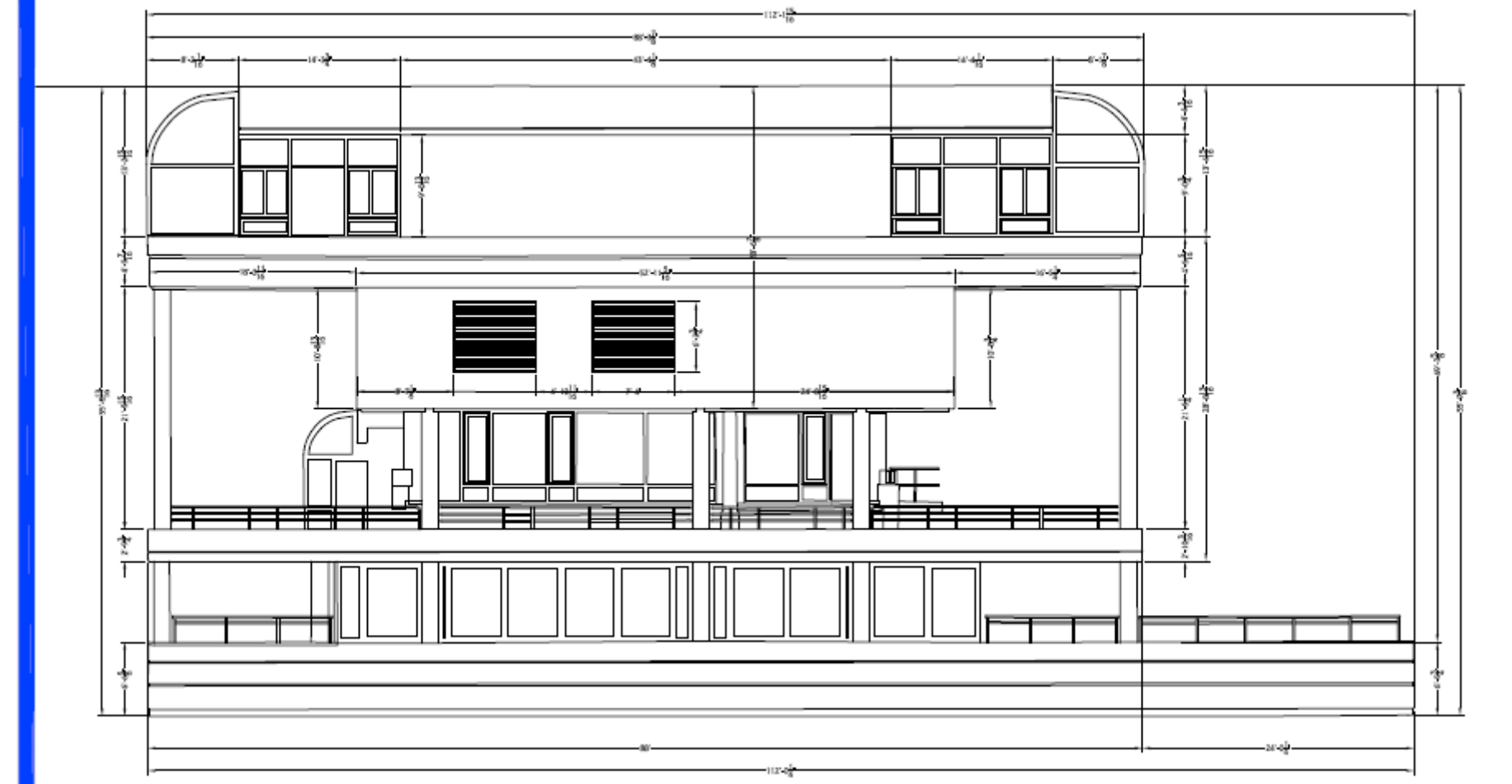
## Deformation Analysis



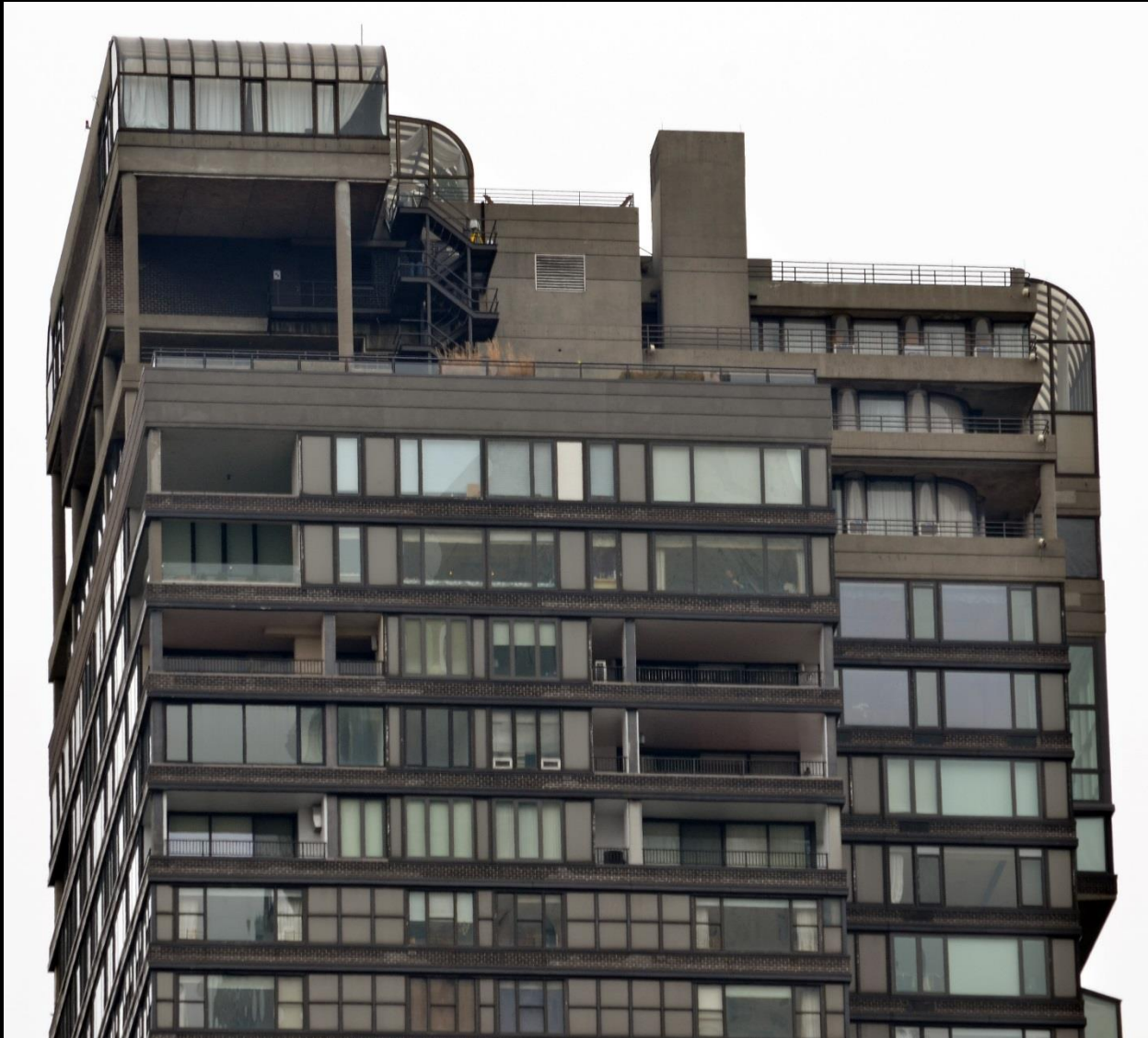
# Model Delivery



# Regular Drawings: Still required



Looks can be **deceiving...**



Looks what's possible **now...**



# QUESTIONS?

Please do!

