

Effect of incident wave on the monitoring of reinforced concrete wall with microwave thermography method

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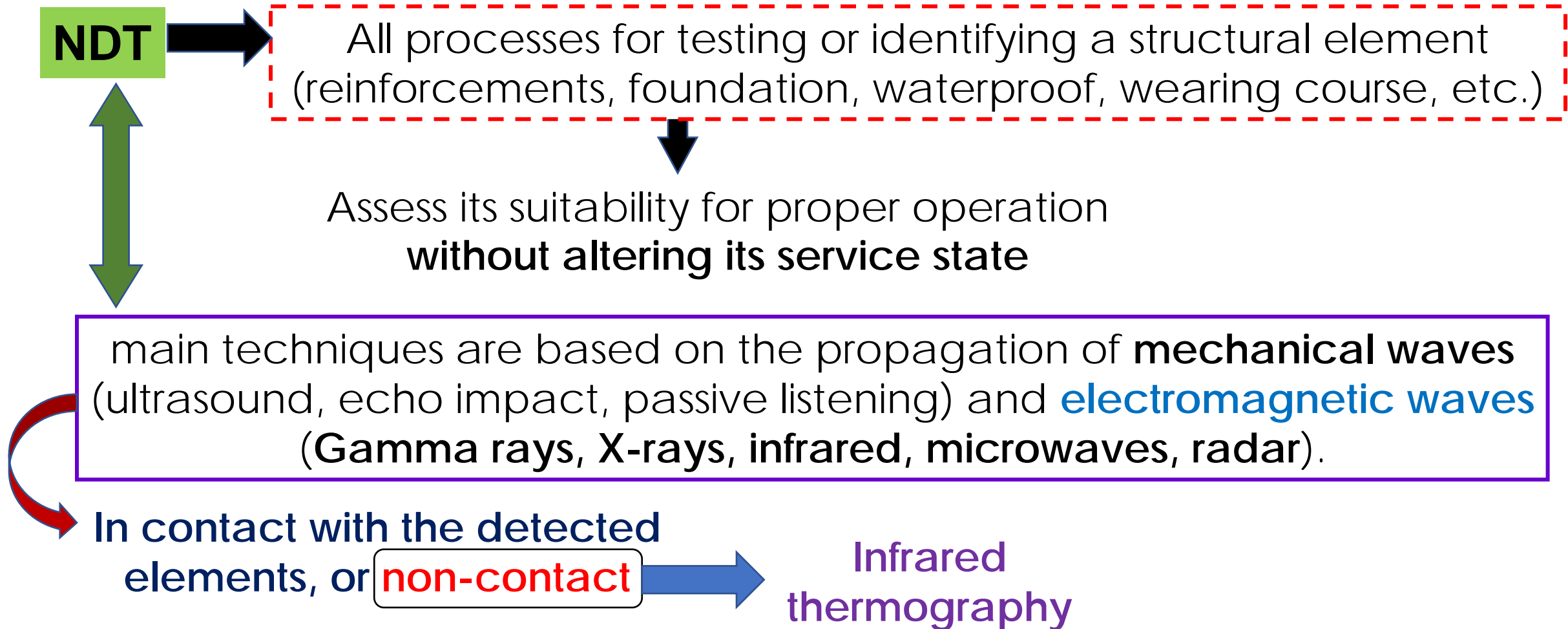
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OUTLINE

- What is *infrared thermography method*?
- *How* can the method be developed?
- *Applications* of the method for *structural health monitoring (SHM)*?
- Physical *phenomena in steel detection* in reinforced concrete wall?
- Remarks and Perspectives

❖ What is *infrared thermography method*?



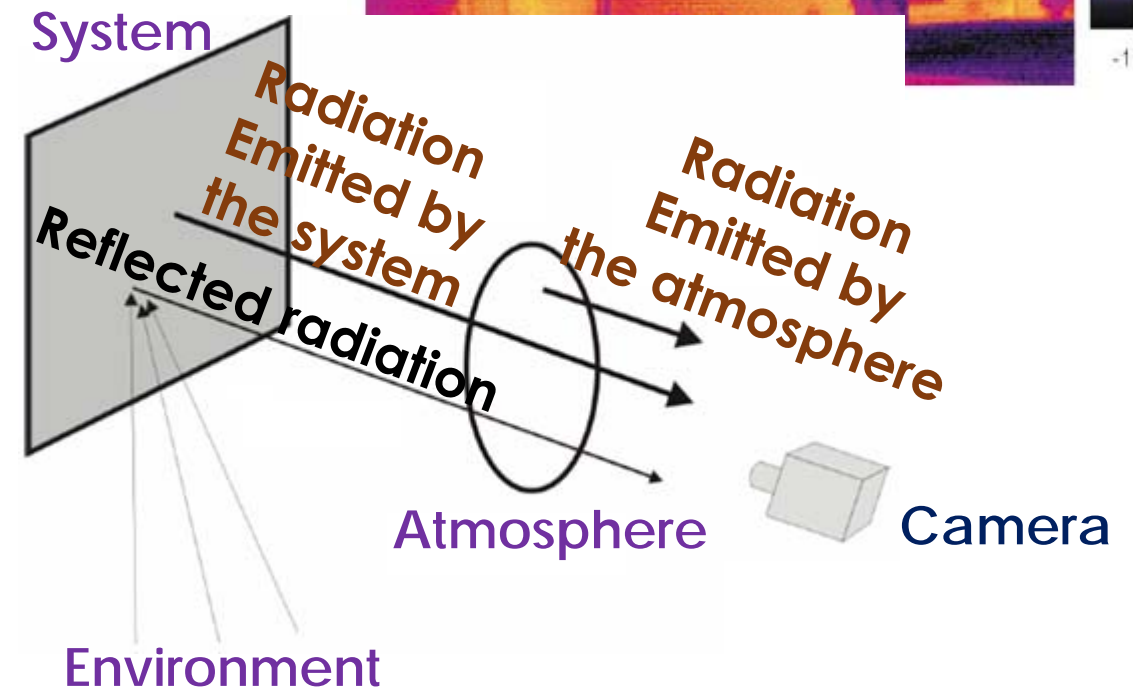
❖ What is *infrared thermography* method?

Infrared thermography: non-contact technique for measuring the temperature based on heat transfer by thermal radiation



an **NDE technique**, that is based on measuring the **temperature difference at the surface** of materials or structures to detect the presence of problems, defects, or variations of **thermal conduction properties** beneath the surface

(X. P. V. Maldague, 2001)

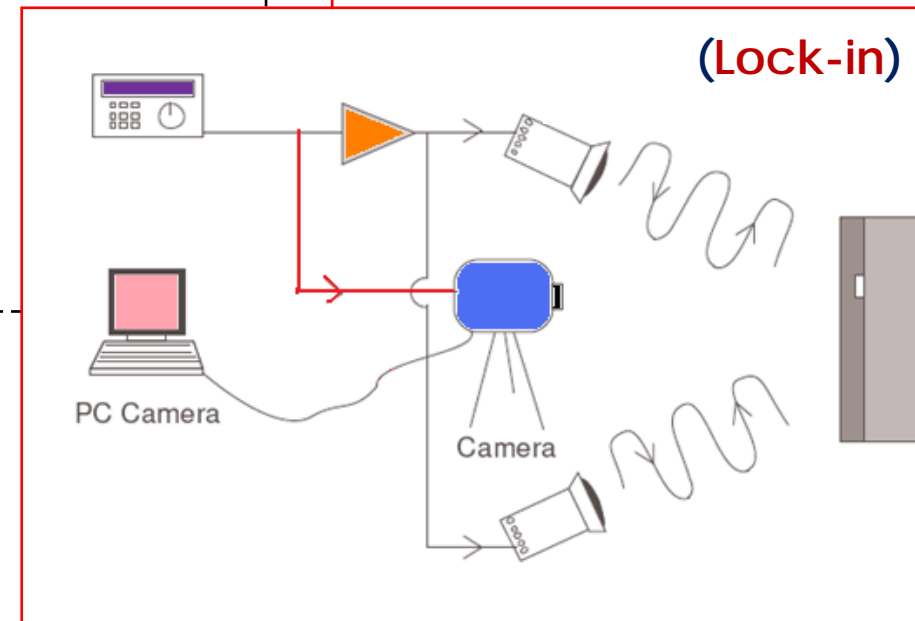
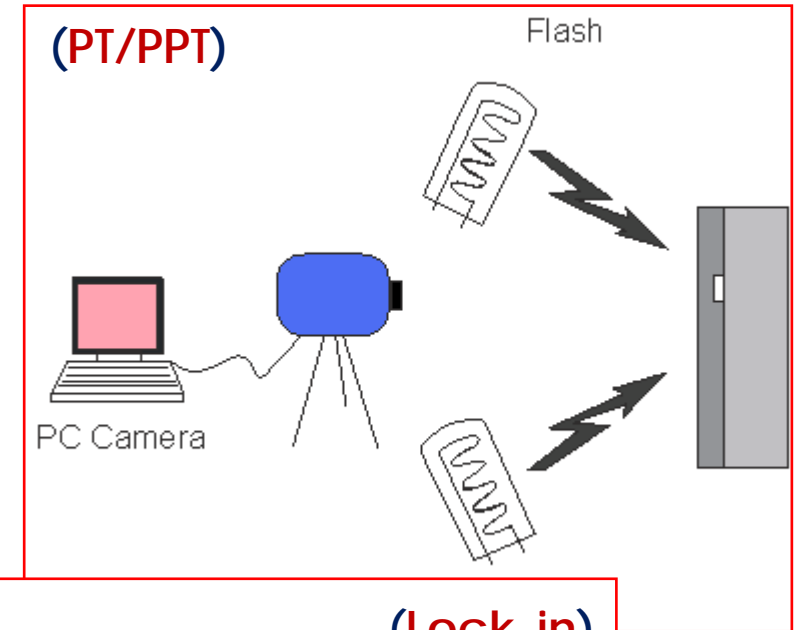


❖ How can the method be developed?

1. Interpretation methods

Development modes in active infrared thermography methods:

- ✓ Pulse Thermography (PT)
- ✓ Lock-in Thermography
- ✓ Pulsed Phase Thermography (PPT)

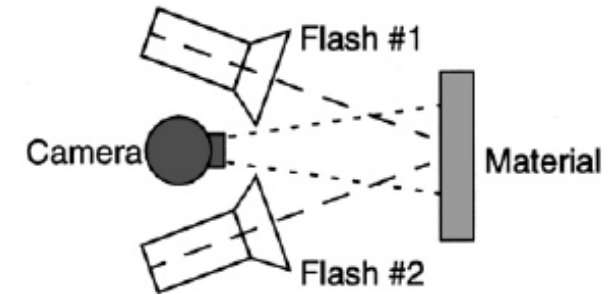


❖ *How can the method be developed?*

2. Excitation systems (heating sources)

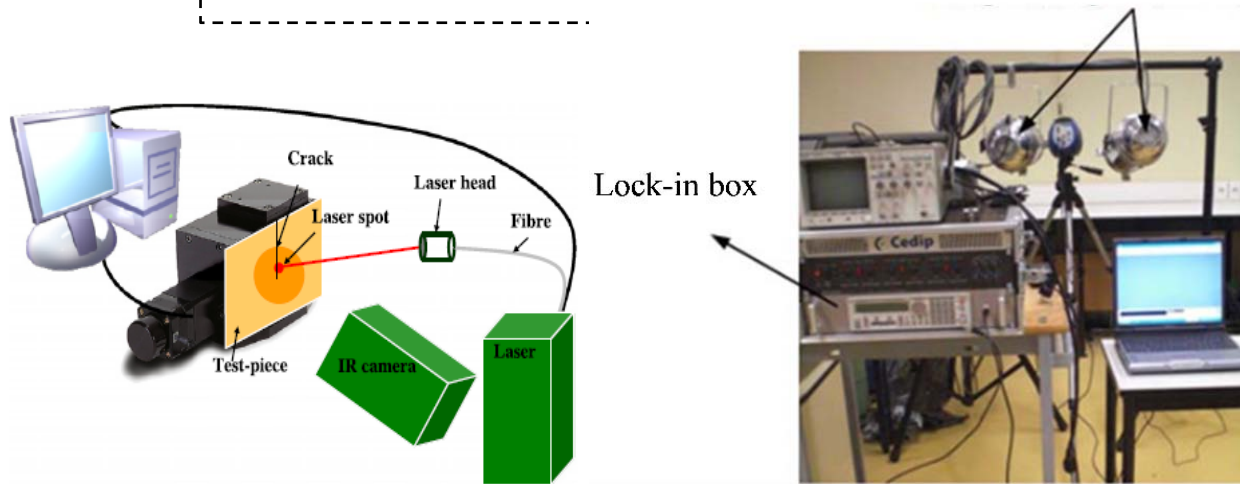
- **Laser**
- **Halogen lamps**
- **Flash**
- **Induction**
- **Microwave** heating source 
- ...

Halogen lamps (500 W)



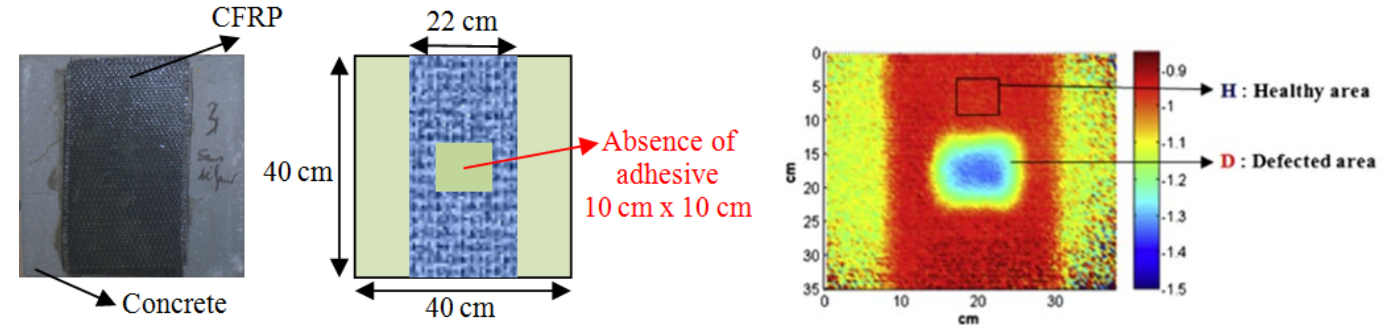
Advantages:

- **volumetric** nature
- **rapidity** of the technique is attributed to the heating of a **specific volume** of the specimen at a given time.



❖ Applications of the method for structural health monitoring (SHM)?

- Spot weld inspection
- Cracks, cavity in concrete
- Defects in reinforcement with a carbon fiber-reinforced polymer (CFRP)
- Steel detection in RC structures?



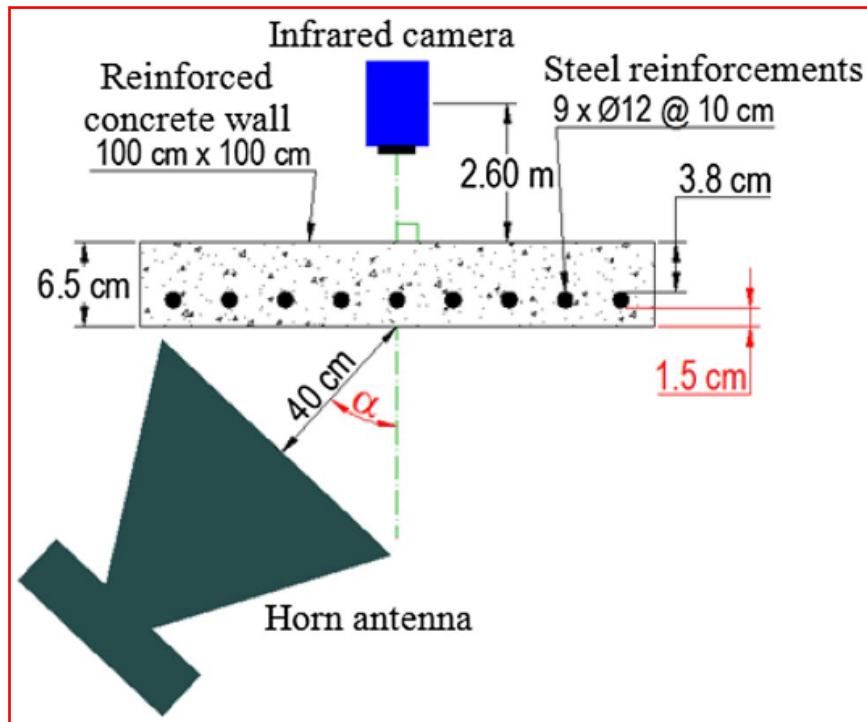
Microwave thermography

How?

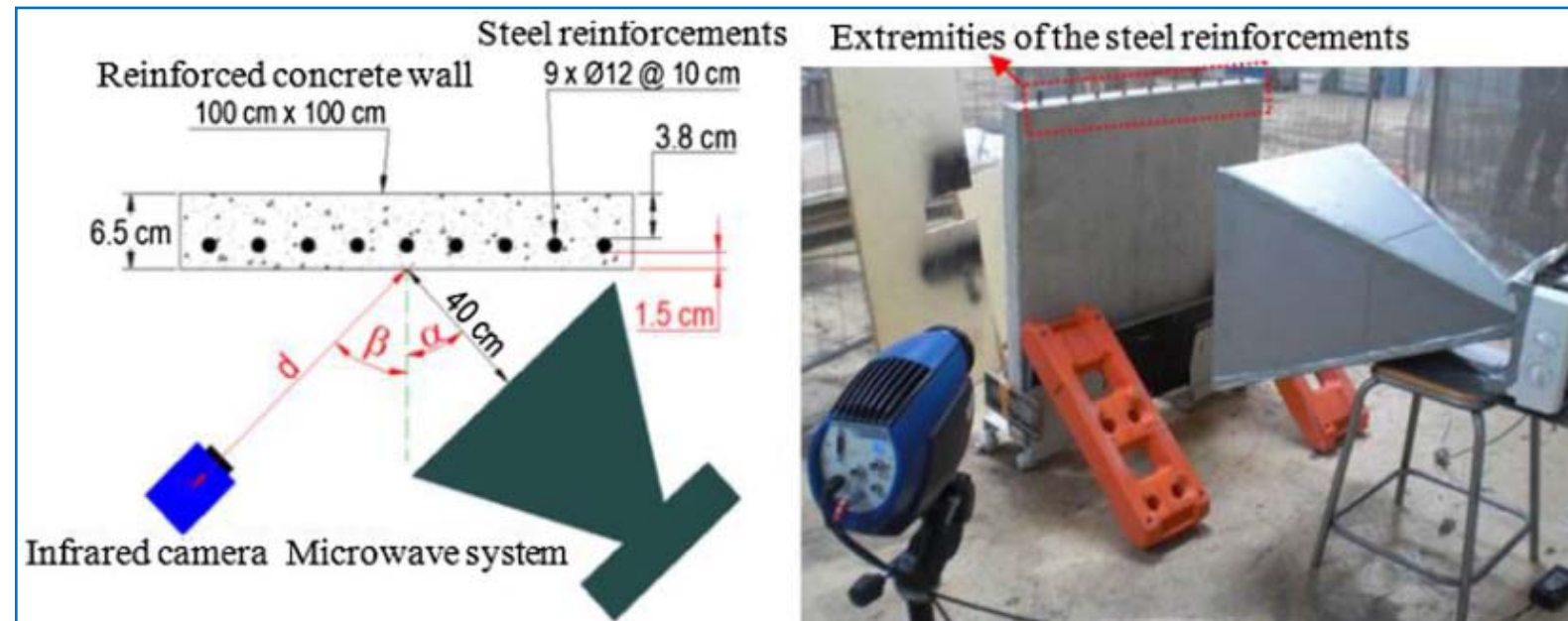
❖ *Applications of the method for structural health monitoring (SHM)?*

Microwave thermography

Transmission approach



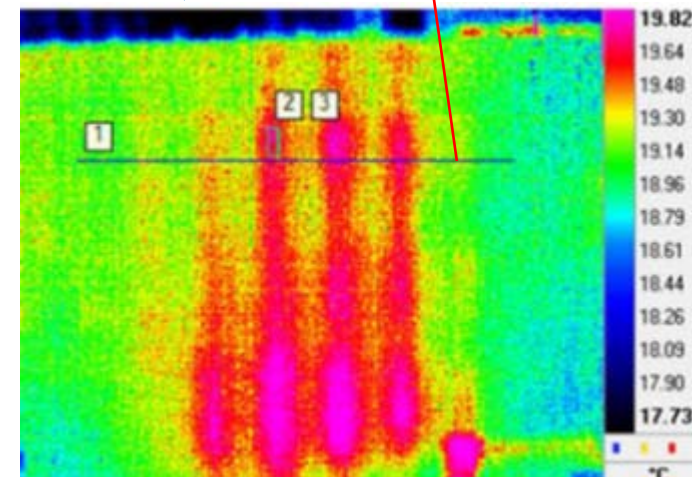
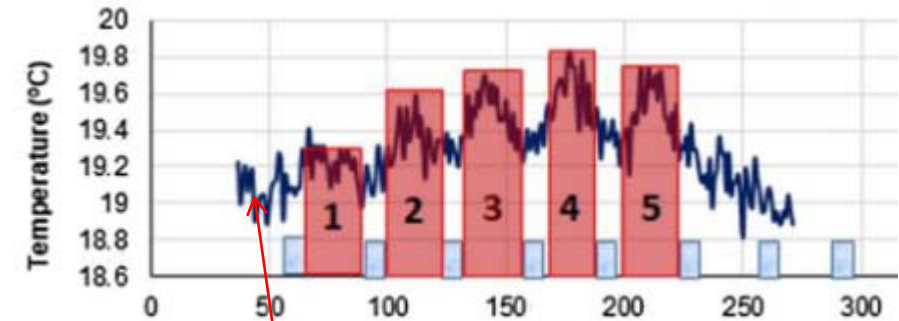
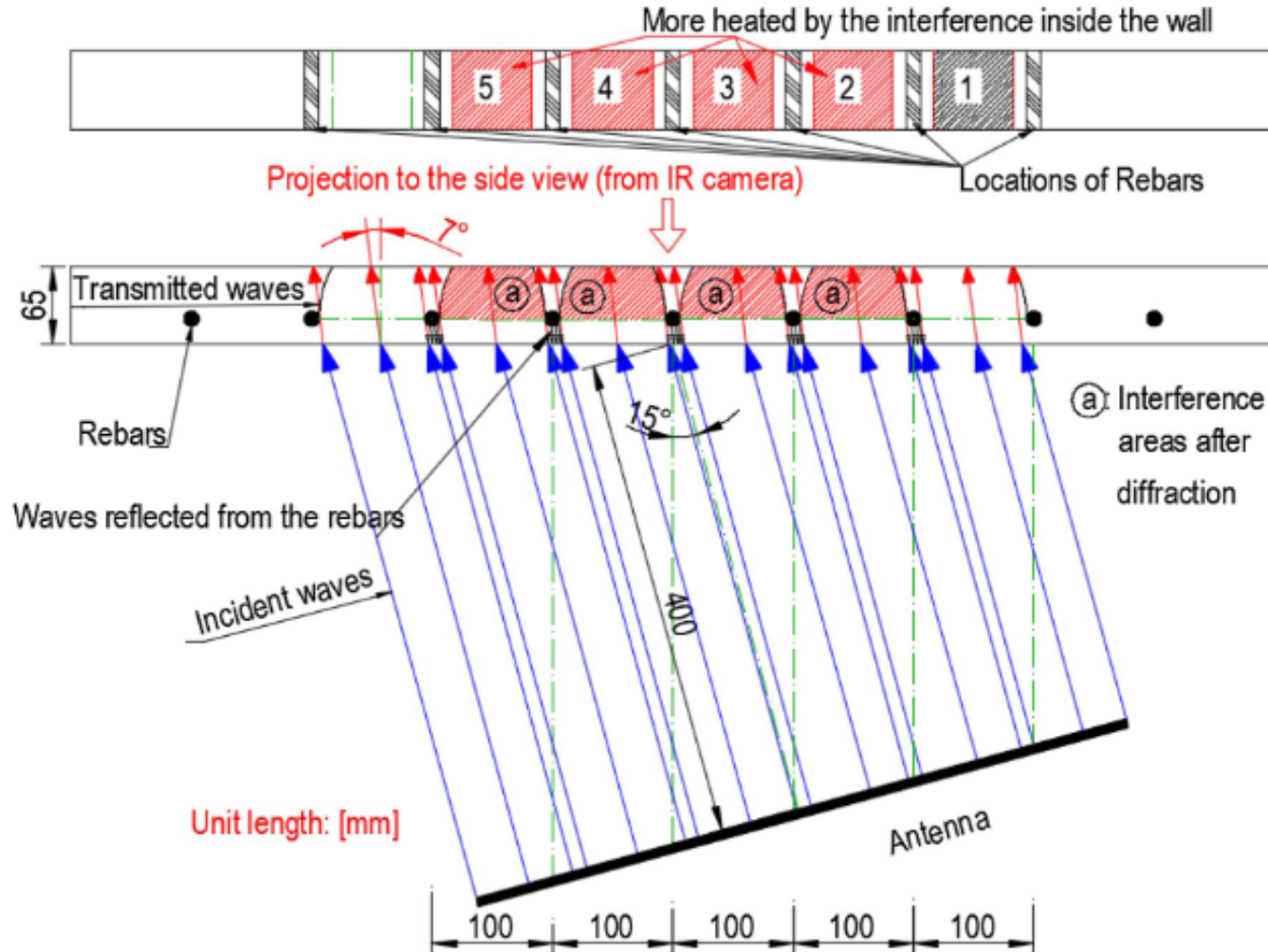
Reflection approach



❖ *Physical phenomena?*

Transmission approach

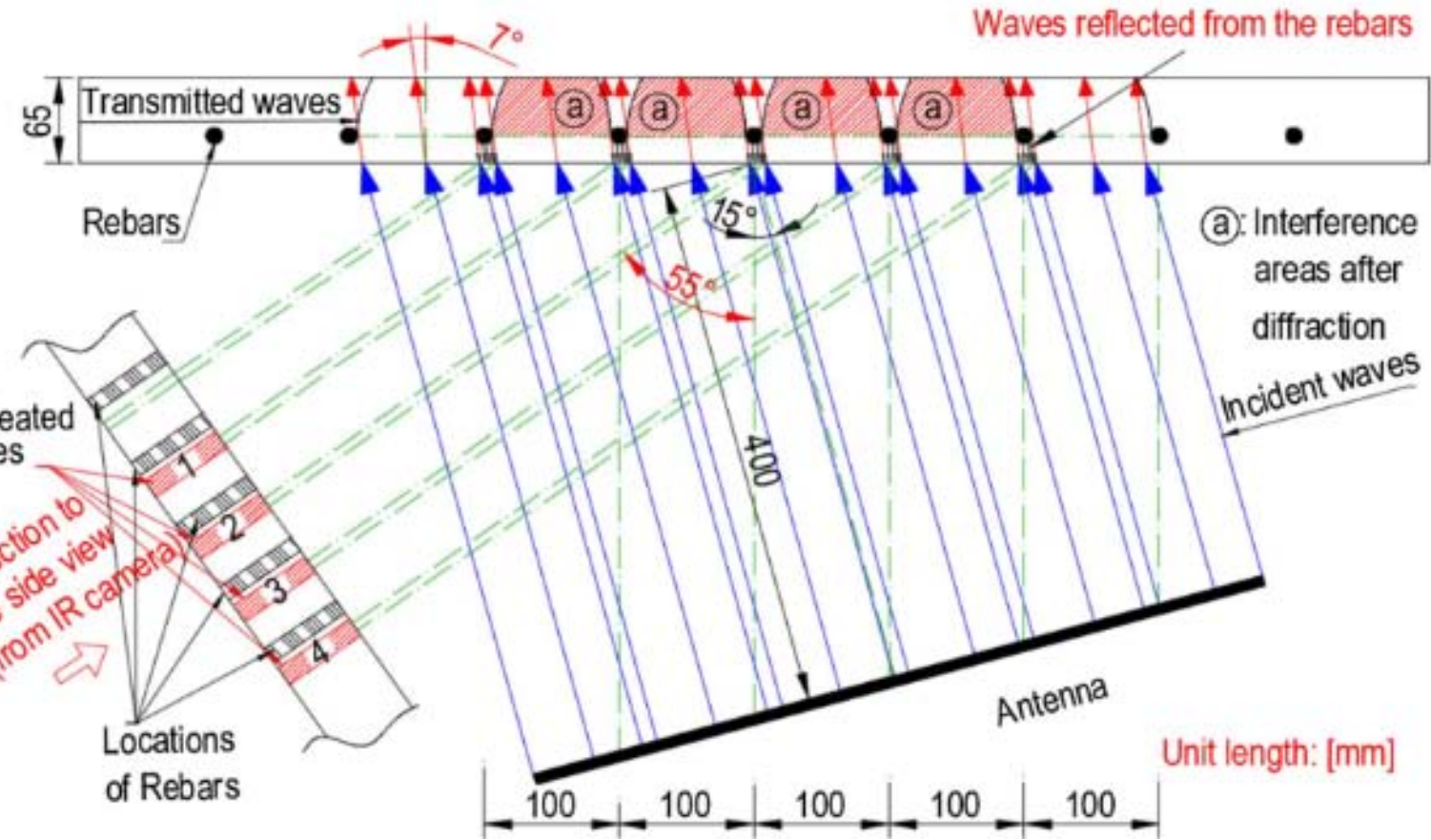
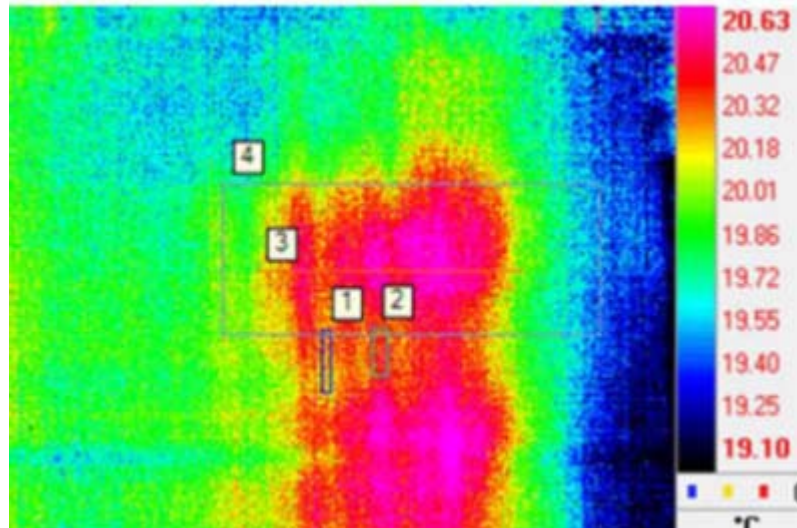
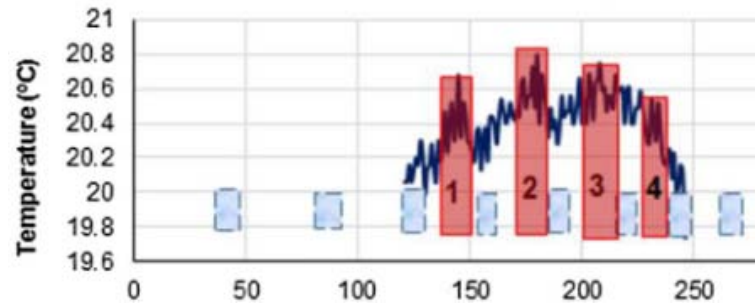
Tests with five angles of incident waves (0°, 15°, 30°, 45°, and 60°)

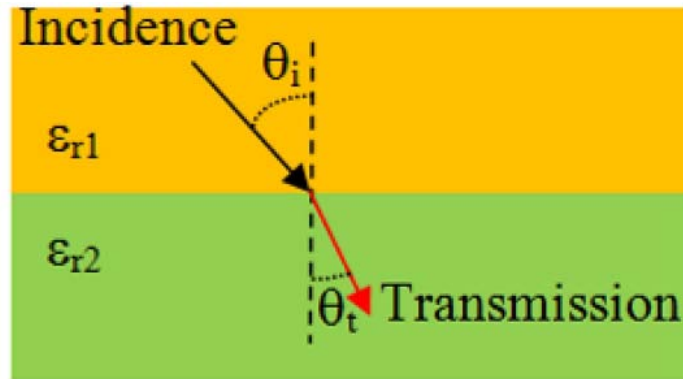


❖ *Physical phenomena?*

Reflection approach

Tests with five angles of incident waves (0°, 15°, 30°, 45°, and 60°)

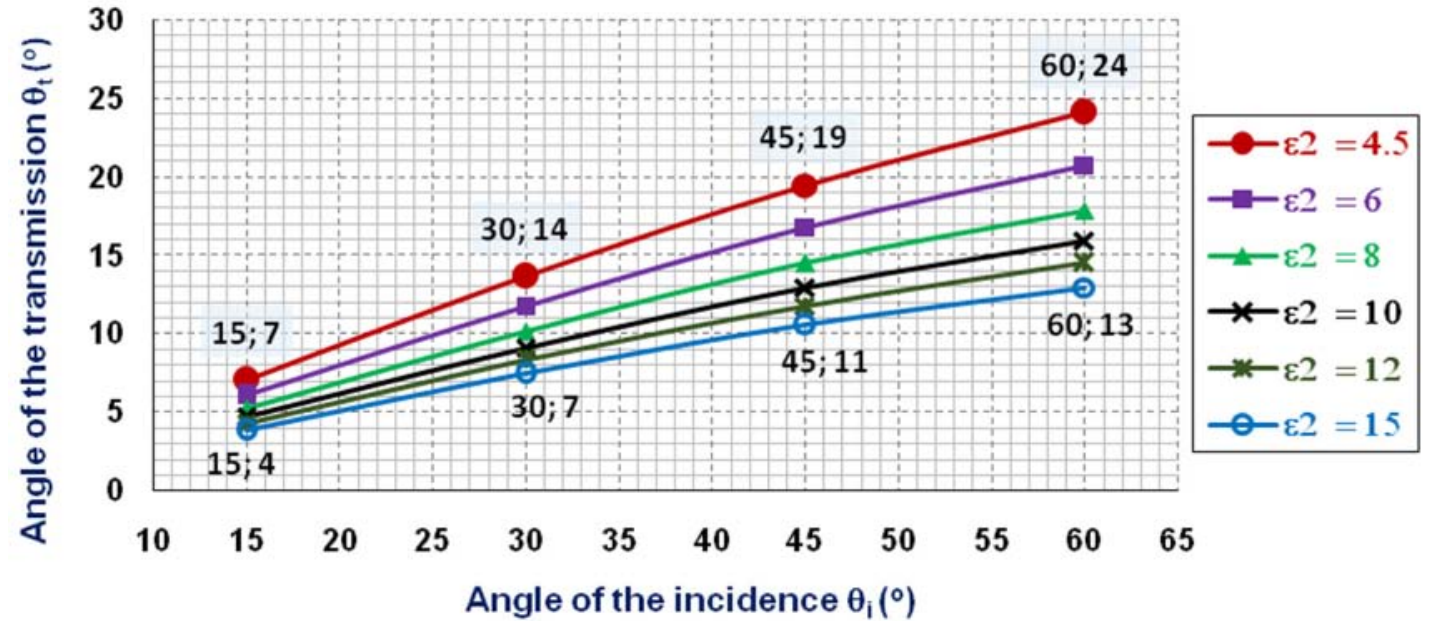


❖ *Physical phenomena?*

Refraction of incident wave
(Snell-Descartes)

Steel reinforcement layer

- **Diffraction**
- **Interference**

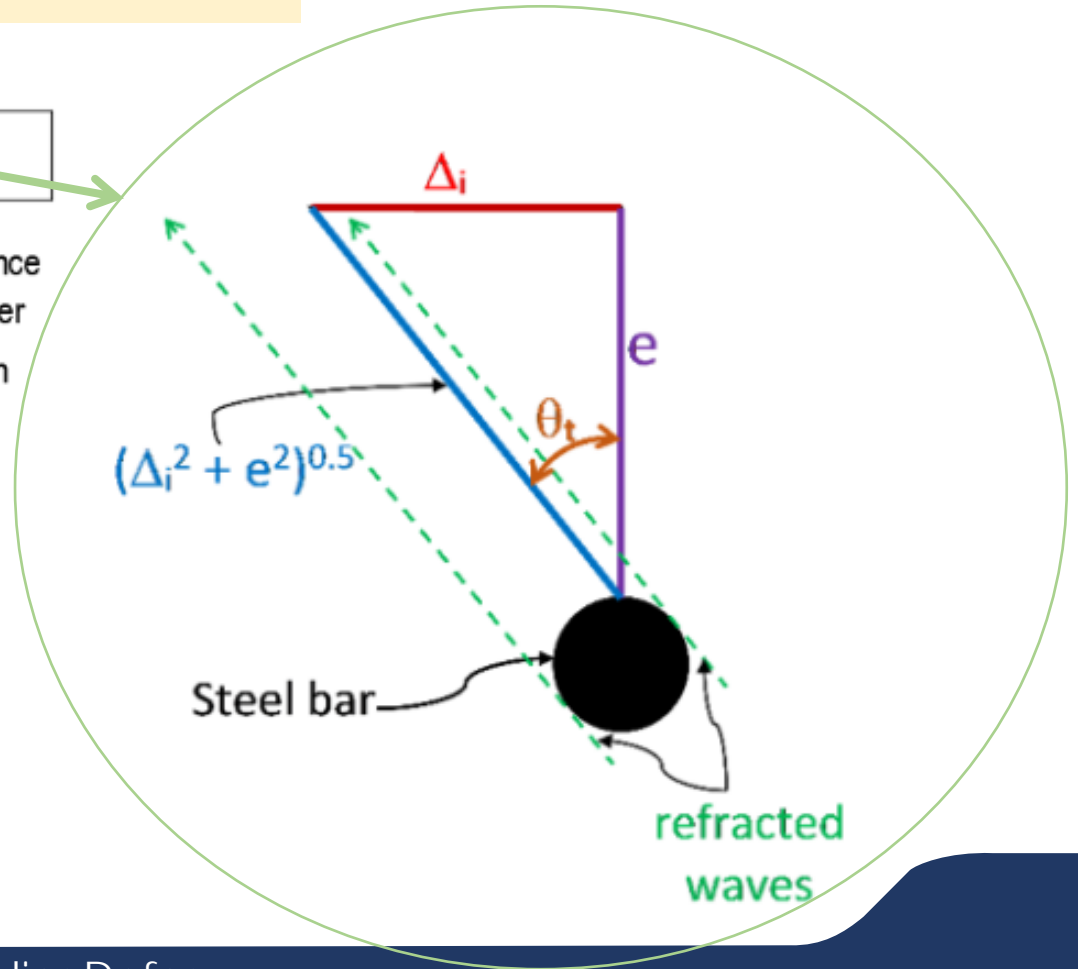
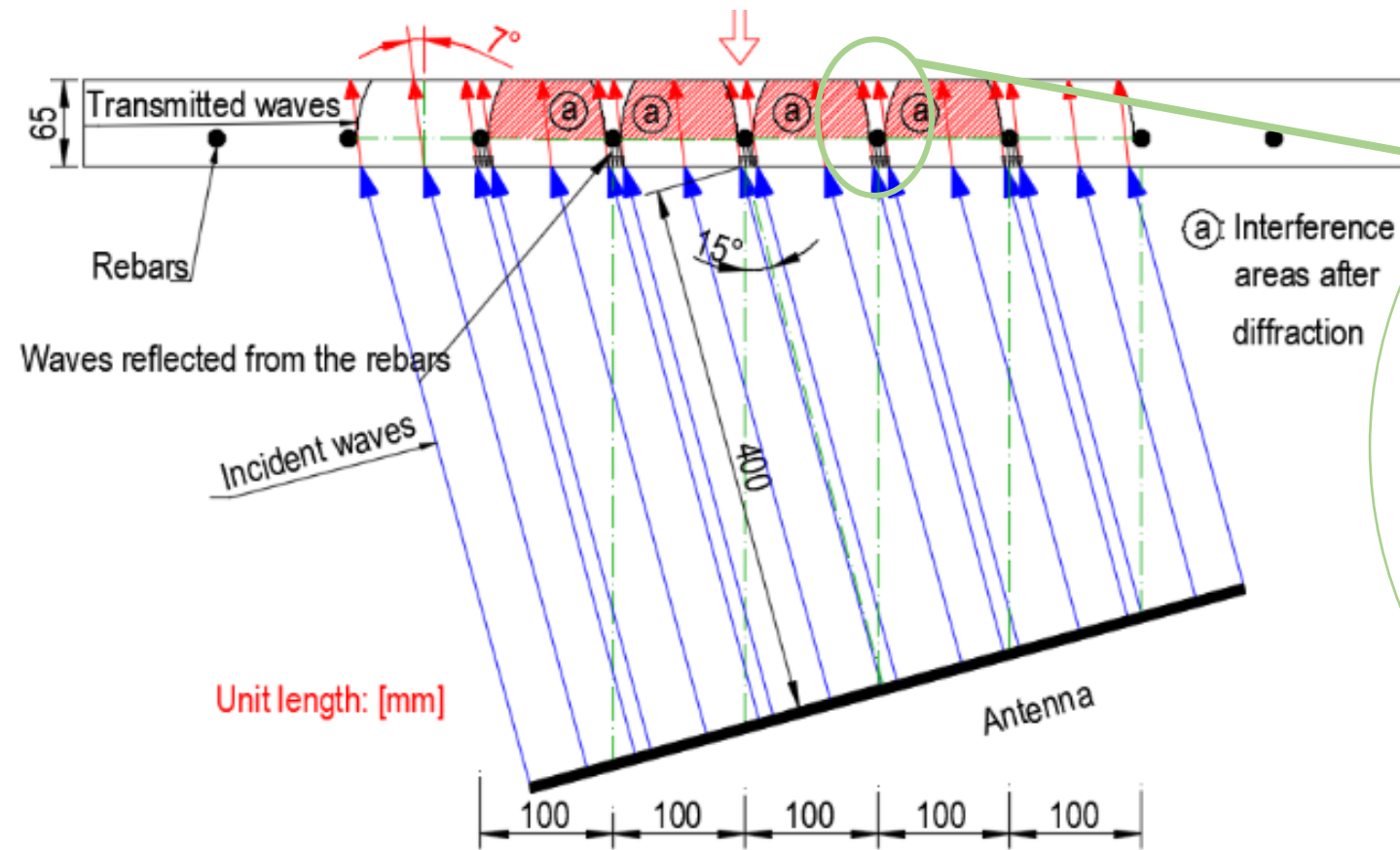


Angles of refracted waves (θ_t) in the function of the incident waves (θ_i) and the **dielectric constant of the concrete (ϵ_2)**

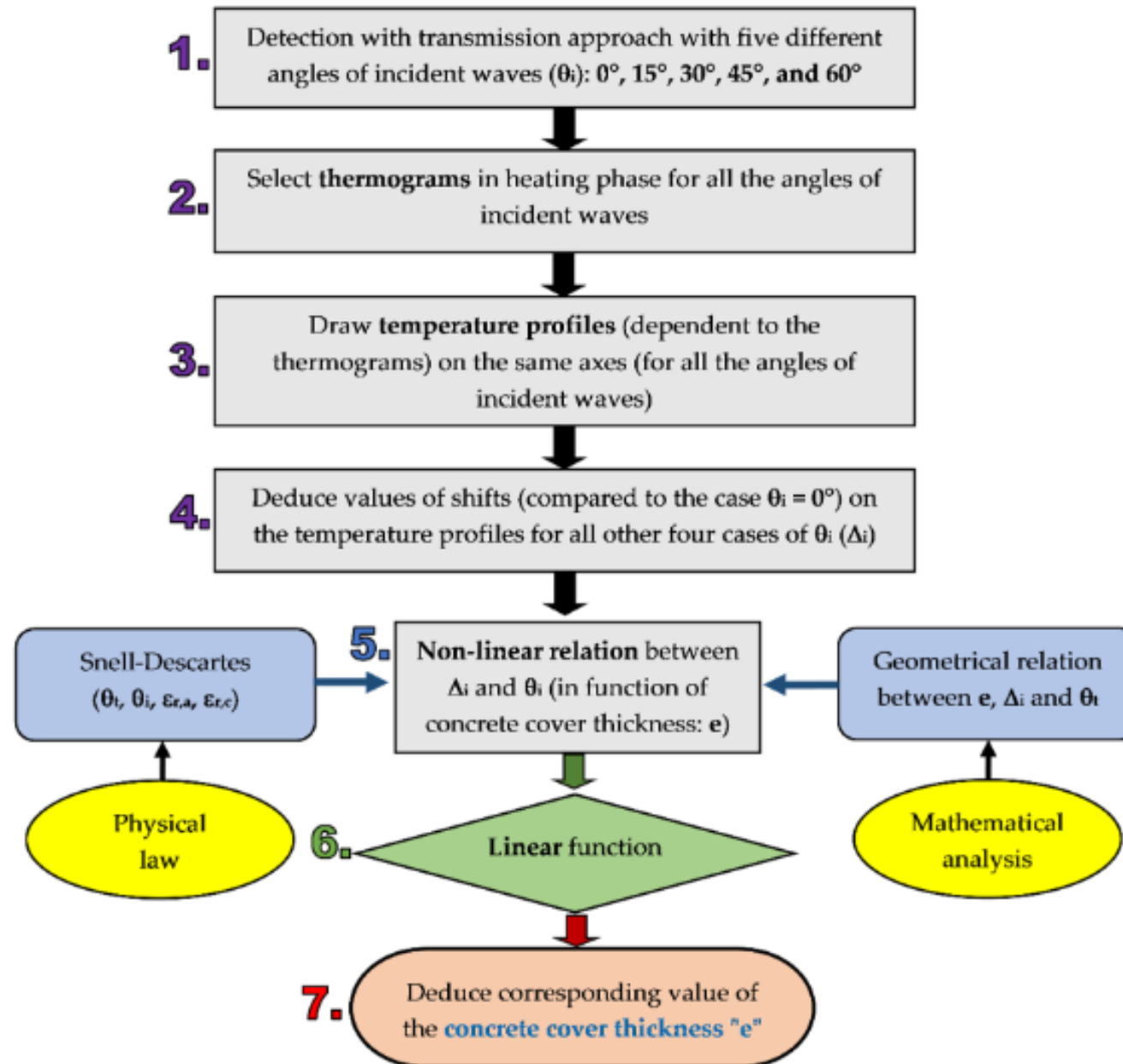
❖ *Physical phenomena?*

- Diffraction
- Interference

then?



❖ Concrete cover
behind the
reinforcement layer by
transmission approach



❖ Remarks and Perspectives

- The penetration of the microwave into concrete depends on *dielectric constant of the concrete*.
- This method can be used in SHM to detect the steel reinforcements and deduce their positions, their spacing and number in RC structures.

- The outcomes from the interpretation of physical phenomena (**interference and diffraction**) the application of microwave thermography with RC wall => allow to deduce the **concrete cover** of the reinforcement layer (by **transmission** approach). This is the new achievement of infrared thermography method.

- Perspectives:
 - Concrete cover by **reflection approach**
 - **State of concrete cover** in **different environmental conditions** (causing corrosion of the steel bars)

References

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Thanks for your attention.

