DAMAGE DETECTION BASED ON MODEL UPDATING METHODS

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ABSTRACT

The paper treats the problem of detecting a structural damage with respect to location and extent from measured vibration test data. The method is based upon a mathematical model representing the undamaged vibrating structure and a local description of the damage, e.g. a finite element for a cracked beam.

A special chapter is devoted to the problem of modelling errors and their influence to damage localization accuracy. An approach is presented how to get reliable results also in this case.

The concept of inverse sensitivity equations is used which can be based on any type of data: e.g. modal data, FRFs, time series or a combination of them.

The resulting inverse problem usually is ill-posed, so that special attention must be payed to its accurate solution. The application to damage detection problems requires the reduction of a large set of damage parameter candidates to a small subset of one or two parameters really describing the local change of the system. An orthogonalization strategy is given to reduce the parameter set. The method is applied to laboratory structures in the frequency domain using FRFs and in the time domain. The results show that the algorithm is able to detect the damage.

EXAMPLE 1 Damage In A Multi Story Frame

properties:

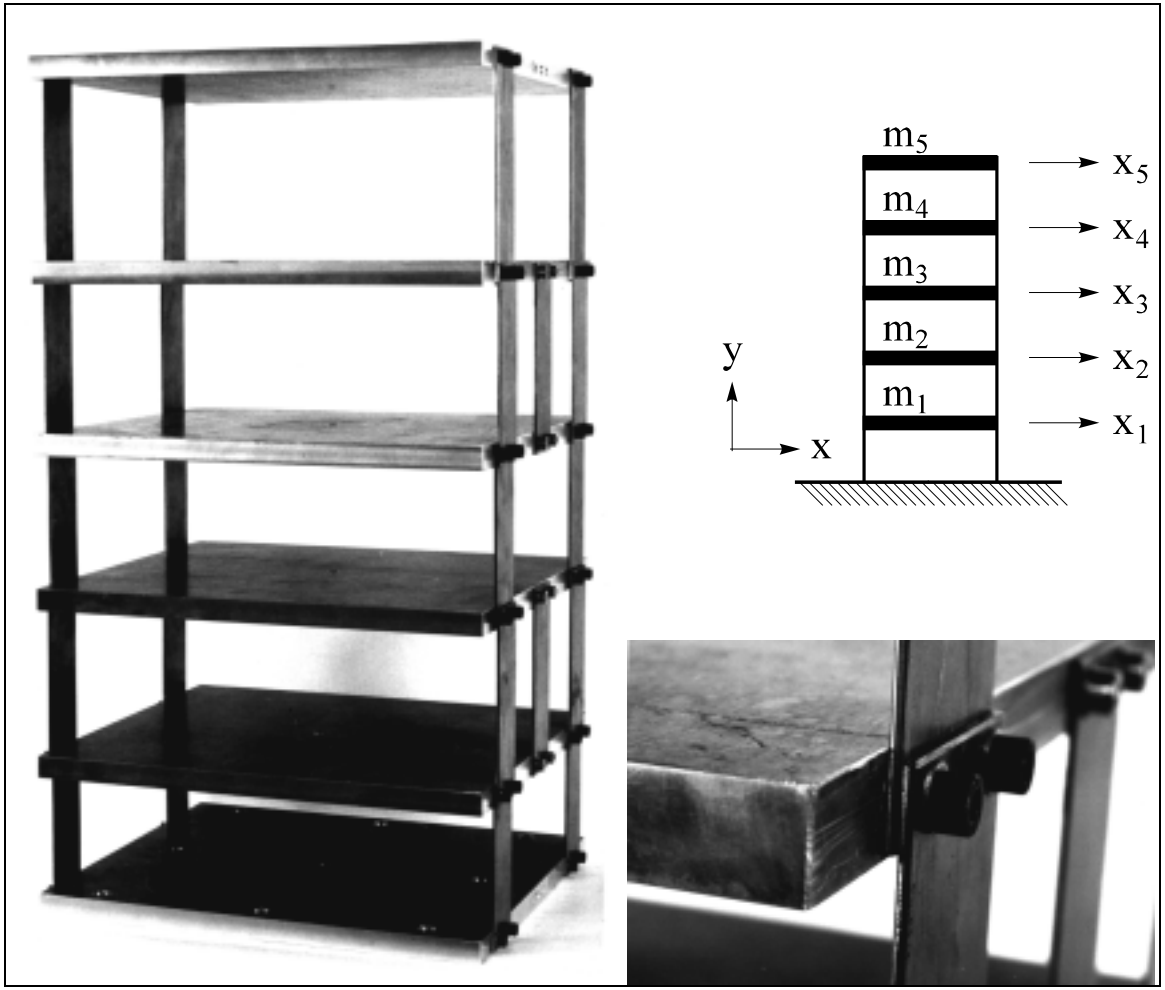
$m_i = 3.6$ kg
$l_i = 8 \div 12$ cm

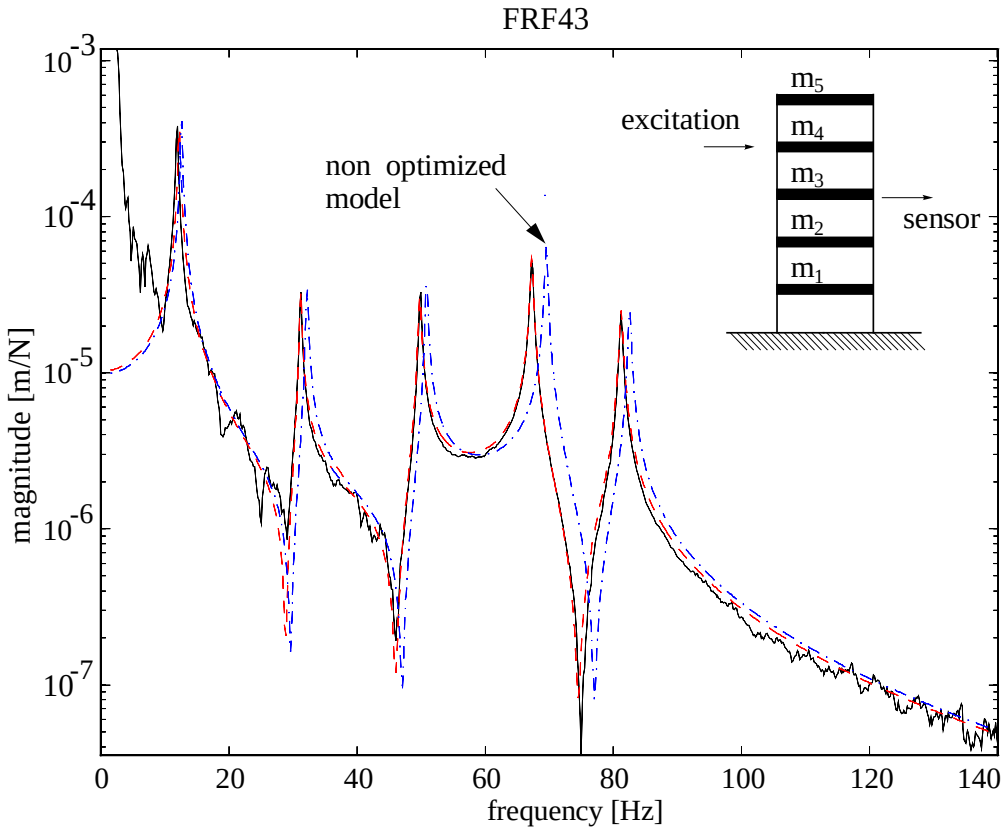
model uncertainty due to screwed connections:

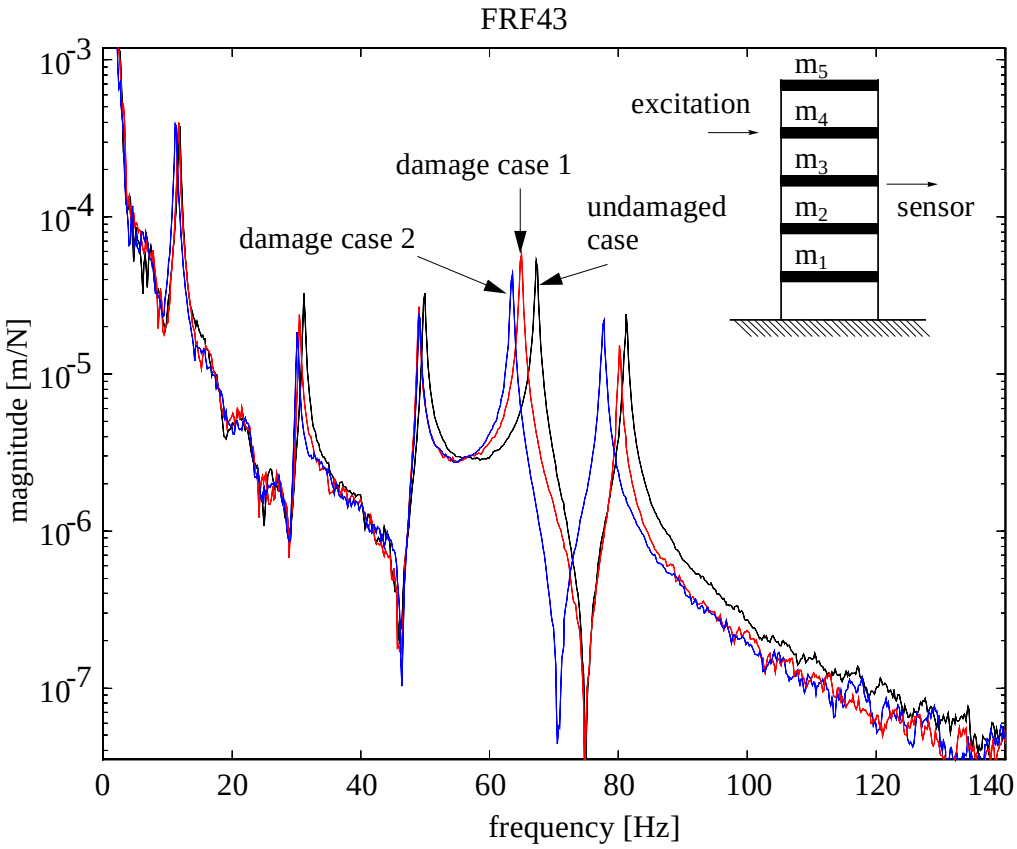
length of steel strips:

$l_{eff} \neq l_{geom}$

($l_{eff} \neq 1.07 \div 1.13\ l_{geom}$)




FRF43
magnitude [m/N]
frequency [Hz]
non optimized
model
excitation
sensor
m5
m4
m3
m2
m1

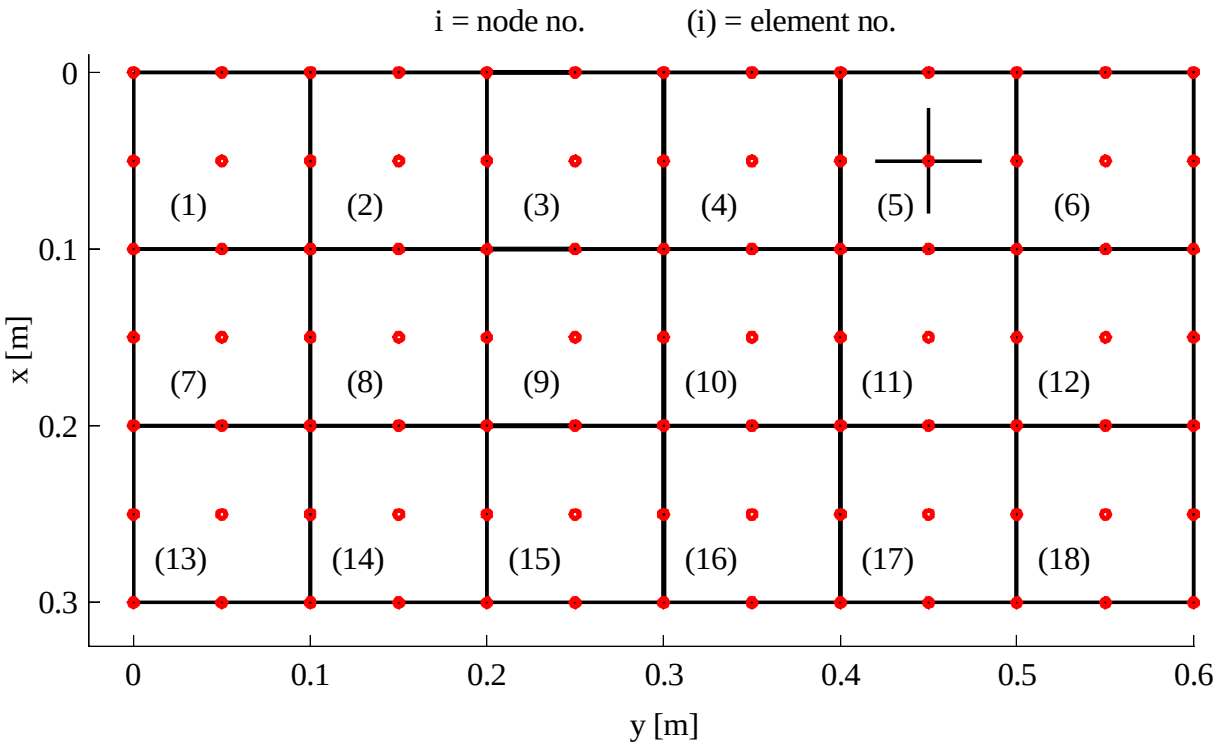

FRF43
magnitude [m/N]
frequency [Hz]
damage case 1
damage case 2
undamaged
case
excitation
sensor
m5
m4
m3
m2
m1

Example 2

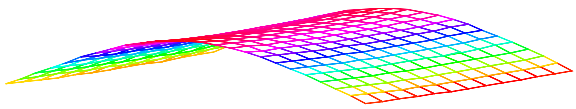
Aluminum plate ($300 \times 600 \times 6$ mm)

18 plate elements
91 nodes
273 DOFs

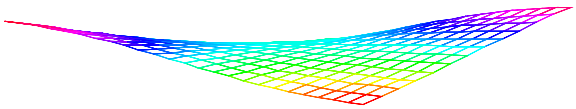
damage: 2 slots



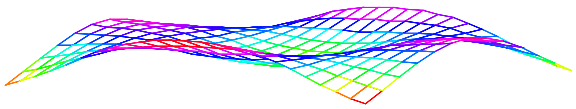
1.natural frequency : 85.32 Hz



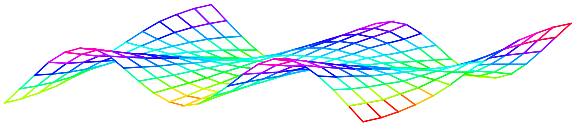
2. natural frequency : 104.50 Hz

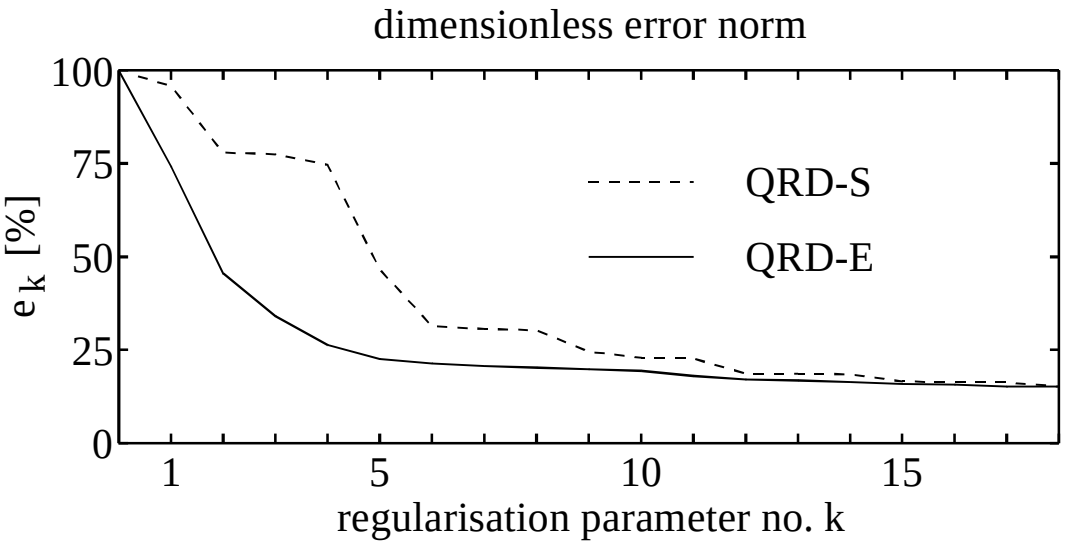


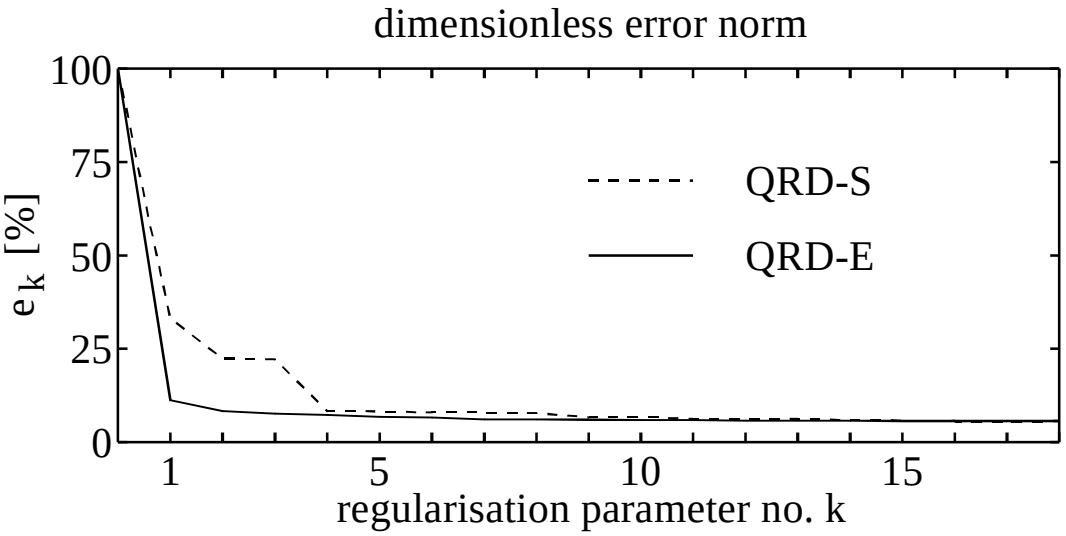
9.natural frequency : 586.55 Hz

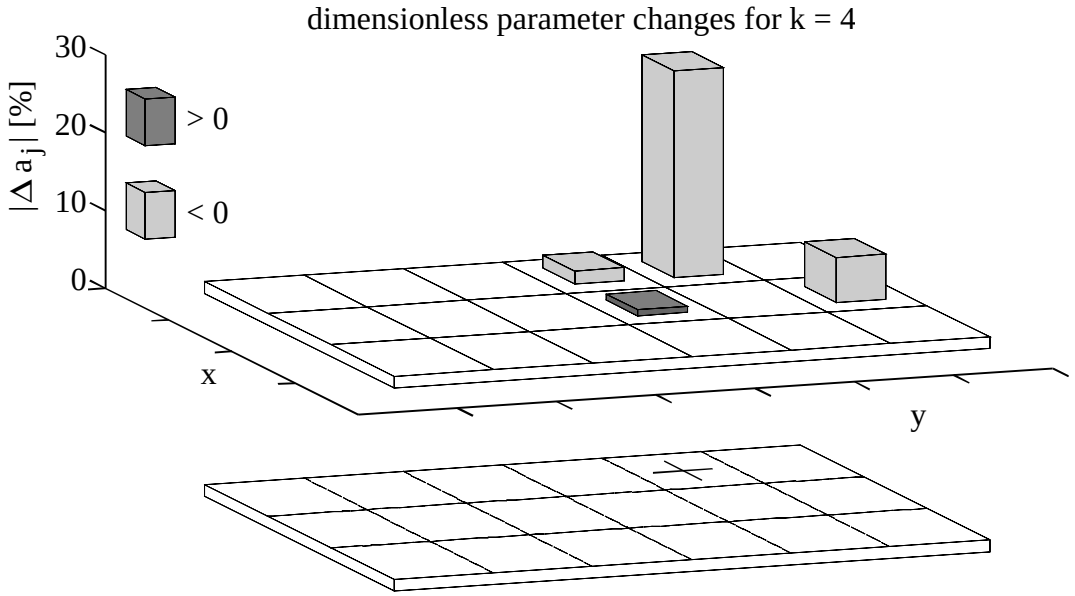


10.natural frequency : 676.57 Hz




dimensionless error norm
100
75
50
25
0
e_k [%]
QRD-S
QRD-E
1
5
10
15
regularisation parameter no. k


dimensionless error norm
100
75
50
25
0
e_k [%]
QRD-S
QRD-E
1
5
10
15
regularisation parameter no. k


dimensionless parameter changes for k = 4
30
20
10
0
$|\Delta a_j|$ [%]
> 0
< 0
x
y