INSTITUTO DE INGENIERÍA UNAM

Coordinación de Automatización

Compuertas Lógicas Ópticas

Los atributos de los dispositivos ópticos así como sus persistentes novedades, armonizados a los dispositivos electrónicos, prometen la admisión a temas tan modernos y complicados como la imitación del procesamiento neuronal humano, el reconocimiento y encriptación de secuencias de datos, la conmutación fotónica en redes de telecomucicaciones, entre muchas aplicaciones más.

A través del proyecto *"Estudio teórico de la implantación de compuertas lógicas fotónicas ultrarrápidas mediante el uso de Amplificadores Ópticos de Semiconductor"* el Instituto de Ingeniería incusiona en la investigación de la tecnología en comunicación óptica.

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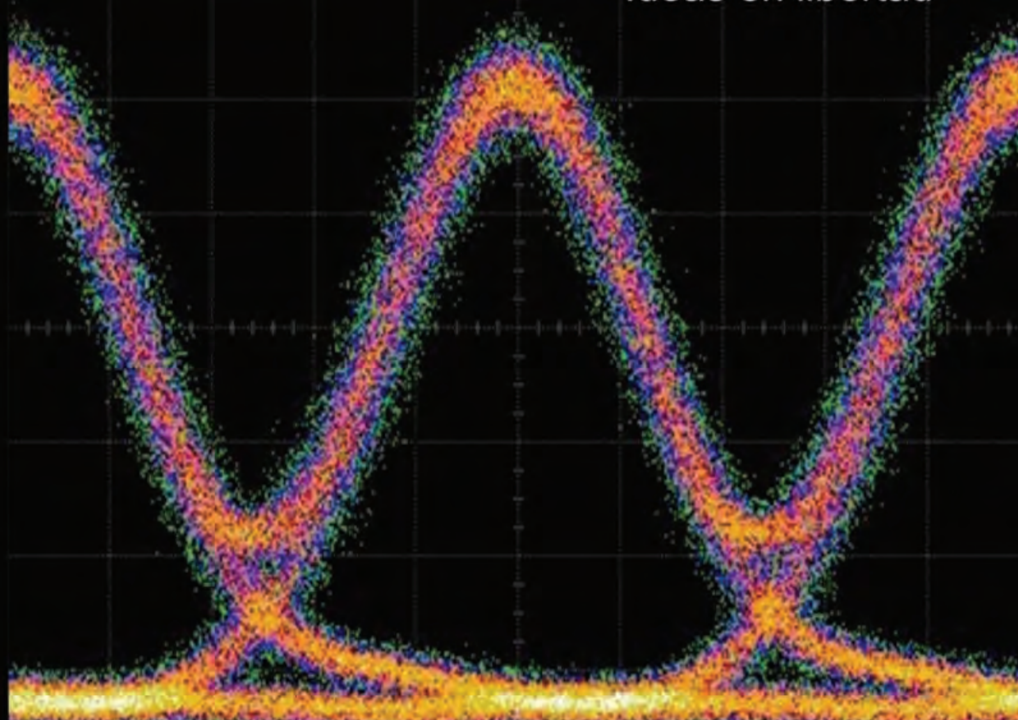

Diagrama de ojo:
Gráfica de estudio en la simulación de uno de los modelos computacionales.

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STRUCTURAL DAMAGE DETECTION WITH THE IMPROVED TRANSFORMATION MATRIX

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SUMMARY

This damage detection method is based on the transformation matrix that operates on the global stiffness matrix of a structure, condensed on the primary degrees of freedom.
The structural damage can be located from an initial non-damage state, by using an iterative procedure.
In this investigation, a more refined solution has been achieved. Now, it is possible to detect damaged structural elements of buildings, and the magnitude of this damage with a better accuracy.
This new formulation has been applied to the study of building structures.

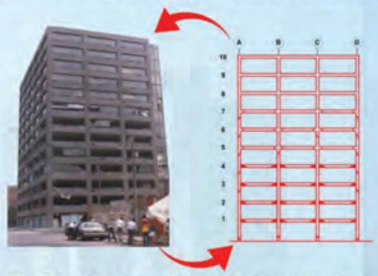


Fig. 1.- Model of structural damage detection of a real structure

THE METHOD

In practice, it is not possible instrument a structure in all its degrees of freedom (dof). Then, it is necessary to condense it in order to reduce them.

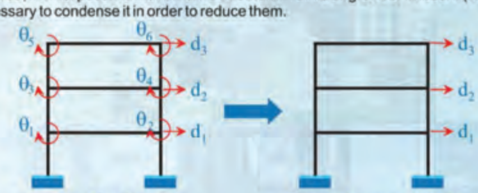


Fig. 2.- Condensation on the primary degrees of freedom

To condense the dof, the transformation matrix [T] is used. This matrix is a function of the identified primary and secondary dof of the structure:

$$[T]=\begin{bmatrix}[I]\\ -[K_{22}]^{-1}[K_{21}]\end{bmatrix} \qquad (1)$$

Where the matrices $[K_{22}]$ and $[K_{21}]$ are submatrices of the static equilibrium equation:

$$\begin{Bmatrix}\{f_1\}\\ \{f_2\}\end{Bmatrix}=\begin{bmatrix}[K_{11}][K_{12}]\\ [K_{21}][K_{22}]\end{bmatrix}\begin{Bmatrix}\{u_1\}\\ \{u_2\}\end{Bmatrix} \qquad (2)$$

Thus, it is possible to carry out the following transformation:

$$[K]=[T]^T[K][T] \qquad (3)$$

On the other hand, the global stiffness matrix of a plane frame for a damaged state $[K_d]$, can be written as:

$$[K_d]=[K_{wd}]-\sum_{i=1}^{nej} dk_i[K] \qquad (4)$$

Where:
$[K_{wd}]$ is the stiffness matrix of the structure without damage
nej is the number of elements of the frame
dk_i is the degradation of stiffness of the *i-th* element ($0 < dki < 1$)
$[K]_i$ is the stiffness matrix without damage of the element *i* of the frame.

The condensed stiffness matrix corresponding to a state of damage of the frame is calculated with the equation 5 and by using the the transformation matrix [*T*] from the eq. 1:

$$[K_d]=[K_{wd}]-\sum_{i=1}^{nej} dk_i[K] \qquad (5)$$

The condensed stiffness matrix has $nti=m(m+1)/2$ independent terms. Developing equation 5 for each term of each matrix:

$$\{k_{wd}\}-\{k_d\}=[S_k]\{dk\} \qquad (6)$$

Where k_{wd}, k_d, and dk are vectors of order *ntix1* containing: the independent terms of the matrix of lateral stiffness of the matrix with and without damage, and the stiffness degradation of the structural elements, respectively; $[S_k]$ is a matrix of order *ntixnej* that contains the independent terms of each structural element.

Because in general, the number of equations *nti* is different from the number of unknowns *nej*, the previous system of equations is non-consistent. A vector that provides an exact solution for the terms of the left side of equation 6 does not probably exist. Then, the system of the equation 6 might be solved like a linear programming problem.

THE REFINEMENT

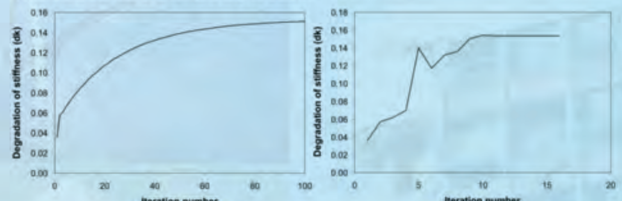
In order to have a convergence criterion, the traditional method presents the equation 7:

$$dk_{n+1}=\beta dk_n+(1-\beta)dk_{n-1} \qquad (7)$$

In this work, It has been possibly to obtain a convergence criterion more refined:

$$dk_{n+1}=dk_n-\Delta_n\frac{dk_n-dk_{n-1}}{\Delta_n-\Delta_{n-1}} \qquad (8)$$

Where Δ_i is the rate of change of the iteration *i*.



A) Using the eq. 7 *b) Using the eq. 8*

Fig. 3.- Example of convergence with the traditional and with the refined criterion

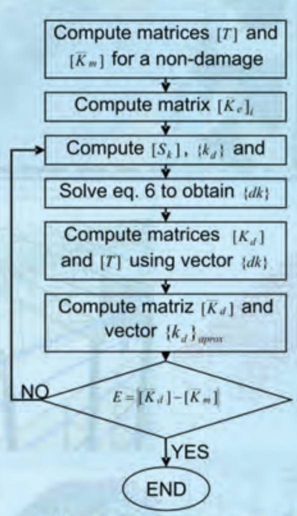


Fig. 4.- Structural damage dectection algorithm

CONCLUSIONS

The localization and assessment of the damage magnitude, defined as the loss of stiffness of the structural elements can be determined by using this metod.
The refinement of the method accelerates the location and assessment of the damage magnitude of the studied cases.
This method has the potential of becoming a useful tool in repair decisions, reinforcement and design of structural systems.

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