The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM), 2025

Volume 38, Pages 69-80

IConTES 2025: International Conference on Technology, Engineering and Science

Development of a Relation Model for Damage Categorization

Akkouche Karim
Mouloud Mammeri University of Tizi-Ouzou

Khelil Nacim
Mouloud Mammeri University of Tizi-Ouzou

Nekmouche Aghiles
Mouloud Mammeri University of Tizi-Ouzou

Kahil Amar
Mouloud Mammeri University of Tizi-Ouzou

Hamizi Mohand
Mouloud Mammeri University of Tizi-Ouzou

Bouzid Leyla
Mouloud Mammeri University of Tizi-Ouzou

Atlaoui Djamel
Mouloud Mammeri University of Tizi-Ouzou

Abstract: After an earthquake, many field investigations are conducted to classify the damage undergone by the buildings. In many cases, it has been found that the global damage category assigned to the construction does not correspond to the damage associated with the building various components (bearing elements, non-bearing elements, infrastructure, environment, etc.). In this paper, a method for the quantitative evaluation of post-earthquake damage of buildings is developed, based on the theory of the design of experiments. This study has been conducted by processing a database of 7.847 damaged buildings extracted from a database collected during a post-earthquake survey (Boumerdes, Algeria, 2003 earthquake). In doing so, firstly, two mathematical models have been developed to quantify the two quantities that assess the state of all the bearing and non-bearing elements (D_{ER}) and (D_{ES}) respectively. Then, a function representing the relationship between the severity of the element-scale damage and the global damage category of the building was developed. Finally, an application of the proposed method has been performed on a set of ten damaged buildings. The results indicate that the proposed method provides a more accurate assessment on the condition of the building compared to the decisions made by the engineers during the Boumerdes earthquake inspection in 2003.

Keywords: Design of experiment method, Elementary damage, Full-factorial design, Global damage, Post-seismic analysis

Introduction

Although the principle of classification is simple to use and rather convenient, however, imprecision's may appear, on the one hand, because the estimation of the overall damage (DG) depends essentially on the expertise and judgment of the expert (Baggio et al. 2007), and son the other hand, because no threshold value is

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

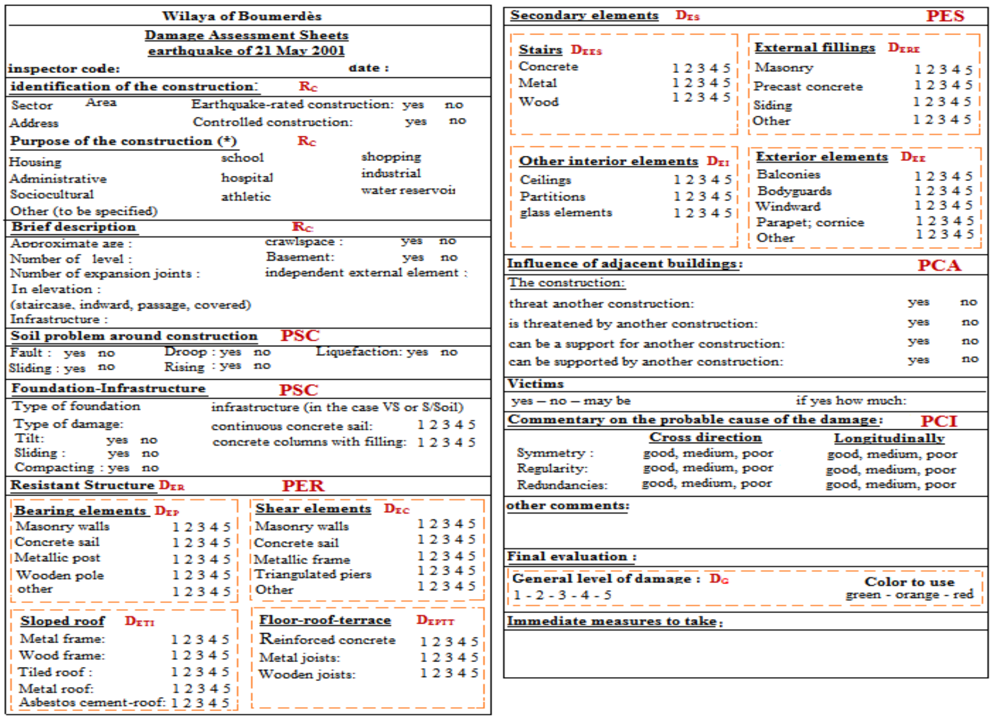
rigorously defined between two successive categories of damage (Sinha et al., 2012; Akkouche et al., 2019). Moreover, the success of the diagnosis (qualitative evaluation) is not mainly linked to the usual standards of damage assessment, but rather to the accuracy of the expert's judgment (Goretti, 2001; Carreño et al., 2010). An incorrect answer from the expert, while recording the appreciation, may be a source of increased uncertainty vis-a-vis the safety of the occupants of an already damaged structure (Davidovichi, 2003).

For that matter, the transition from a qualitative evaluation to a quantitative evaluation proves to be very interesting (Sinha et al., 2012), this, relying on the development of mathematical prediction models that improve the accuracy and objectivity of decisions (Olson & Dash-Wu, 2010). These models are founded on specific databases (construction mode, building area, supporting soil ... etc) which induces a reduction of their applicability. In other words, the use of these models leads to systematic errors. In this perspective, a more adequate damage assessment method corresponding to Algerian construction methods is proposed. The assessment of the overall damage level will be done through the proposed generic model that will reproduce quantitatively the final decision taken by the investigator on a structure (while keeping the same principle proposed by EMS 98 for the evaluation of basic disorders), depending on the severity of the damage reported on its various components. The category of damage associated with a structure is characterized by the achievement of several damage levels noted on the sub-structural elements "the state of the bearing and non-bearing elements, the state of the soil, the state of the neighboring structures …etc." The approach used, where only the damage effects of structural and non-structural components are considered, is based on the theory of experimental design (Goupy, 2000). Indeed, this theory is widely studied and applied in various fields, for prediction, classification and optimization (Akkouche et al., 2020; Akkouche et al., 2024). This work carried out by Akkouche et al showed that this method is applicable to the field of civil engineering. In order to distinguish the characterization of elementary disorders from the assessment of overall damage, this work was conducted as follows:

In a first stage, with reference to the inspection form used by the Algerian authorities, two damage assessment models at the local scale have been established, making it possible to estimate the state of all the elements:

- Bearing, D_{ER} depending on the state of the element: bearing D_{EP}, bracing D_{EC}, floor-roofing-terrace D_{EPTT} and inclined roofing D_{ETI}.
- Non-Bearing, D_{ES} based on the damage level associated with the elements: Stairs D_{EES}, Exterior Filling D_{ERE}, Interior Elements D_{EEI}, and Exterior Elements D_{EE}.

In a second stage, a study has been conducted for the assessment of the parameter, which characterizes the state of the overall construction D_G according to local damages D_{ER} and D_{ES}.



Wilaya of Boumerdès
Damage Assessment Sheets
earthquake of 21 May 2001
inspector code: **date :**
identification of the construction: R_C
Sector Area Earthquake-rated construction: yes no
Address Controlled construction: yes no
Purpose of the construction (*) R_C
Housing school shopping
Administrative hospital industrial
Sociocultural athletic water reservoir
Other (to be specified)
Brief description R_C
Approximate age : crawlspace : yes no
Number of level : Basement: yes no
Number of expansion joints : independent external element :
In elevation :
(staircase, indward, passage, covered)
Infrastructure :
Soil problem around construction PSC
Fault : yes no Droop : yes no Liquefaction: yes no
Sliding : yes no Rising : yes no
Foundation-Infrastructure PSC
Type of foundation infrastructure (in the case VS or S/Soil)
Type of damage: continuous concrete sail: 1 2 3 4 5
Tilt: yes no concrete columns with filling: 1 2 3 4 5
Sliding : yes no
Compacting : yes no
Resistant Structure D_{ER} PER
Bearing elements D_{EP}
Masonry walls 1 2 3 4 5
Concrete sail 1 2 3 4 5
Metallic post 1 2 3 4 5
Wooden pole 1 2 3 4 5
other 1 2 3 4 5
Shear elements D_{EC}
Masonry walls 1 2 3 4 5
Concrete sail 1 2 3 4 5
Metallic frame 1 2 3 4 5
Triangulated piers 1 2 3 4 5
Other 1 2 3 4 5
Sloped roof D_{ETI}
Metal frame: 1 2 3 4 5
Wood frame: 1 2 3 4 5
Tiled roof : 1 2 3 4 5
Metal roof: 1 2 3 4 5
Asbestos cement-roof: 1 2 3 4 5
Floor-roof-terrace D_{EPTT}
Reinforced concrete 1 2 3 4 5
Metal joists: 1 2 3 4 5
Wooden joists: 1 2 3 4 5
Secondary elements D_{ES} PES
Stairs D_{EES}
Concrete 1 2 3 4 5
Metal 1 2 3 4 5
Wood 1 2 3 4 5
External fillings D_{ERE}
Masonry 1 2 3 4 5
Precast concrete 1 2 3 4 5
Siding 1 2 3 4 5
Other 1 2 3 4 5
Other interior elements D_{EI}
Ceilings 1 2 3 4 5
Partitions 1 2 3 4 5
glass elements 1 2 3 4 5
Exterior elements D_{EE}
Balconies 1 2 3 4 5
Bodyguards 1 2 3 4 5
Windward 1 2 3 4 5
Parapet; cornice 1 2 3 4 5
Other 1 2 3 4 5
Influence of adjacent buildings: PCA
The construction:
threat another construction: yes no
is threatened by another construction: yes no
can be a support for another construction: yes no
can be supported by another construction: yes no
Victims
yes – no – may be if yes how much:
Commentary on the probable cause of the damage: PCI
Cross direction Longitudinally
Symmetry : good, medium, poor good, medium, poor
Regularity: good, medium, poor good, medium, poor
Redundancies: good, medium, poor good, medium, poor
other comments:
Final evaluation :
General level of damage : D_G **Color to use**
1 - 2 - 3 - 4 - 5 green - orange - red
Immediate measures to take:

Figure 1. Post-seismic damage assessment form in Algeria (Akkouche et al. 2020)

Evaluation Procedure for Post-Seismic Damages

In order to optimize the work of the engineer and reduce the post-seismic danger, as in many seismic countries, in Algeria, a visual evaluation sheet was developed by the CTC and CGS agencies (Fig. 1). Depending on parameters such as type of use, type of damaged elements, severity of damage, etc. This sheet is intended to give an assessment (local "of the components" and global "of the structure") summarizing the state of damage of the structure. About fifty pieces of information are grouped in this form, of the following type especially:

- General (noted RI for the investigator and RC for the construction).
- Concerning the environment around the construction (soil problems and problems related to adjacent constructions).
- Relative to the state of the bearing and non-bearing elements
- On the different architectural damage causes, noted PCI.
- An overall assessment of the construction damage noted D_G.

The disorders classification adopted in the form is founded on the European Macro-Seismic Scale EMS98 (see Table 1). In addition, depending on this D_G parameter, each construction is marked with a specific color.

Table 1. Classification of reinforced concrete structures according to EMS 98 (Grünthal and Levret 2001)

EMS 98 Scale	1	2	3	4	5
Masonery structures					
Reinforced concrete structure					

Methodology

With the aim of developing a model making it possible to estimate the degree of damage at the construction scale, in this section, the process of processing a database (7,847 inspection sheets) using of the experimental design method is briefly described.

Principal of the Experimental Design Method

Experimental design method has multiple objectives, among which, one is to create a logical relationship (mathematical) between two types of variables (Dagnelie 2000), the physical quantity studied (response) and the physical quantities supposedly having an influence on the response value (factors). According to (Goupy and Creighton 2006), these approaches are characterized by:

- The choice of experimental design,
- The choice of mathematical model expression,

Choice of Experimental Design

According to (Telforda, 2007), only two factors can influence the choice of an experimental plan: the field of study and the degree of precision sought. Referring to the recommendations given by (Dagnelie, 2000), with the aim of developing a model allowing the reproduction of the most complete information, in this study we favored the use of the complete factorial design.

Choice of Mathematical Model Expression

In the case of a study aimed at estimating the weight of variables, polynomial modeling is recommended (Chlela, 2008). Assuming that the effects of the factors are totally additive and that there may be interactions between them, the relationship between the measured responses and the variables can be expressed as a first-degree polynomial (Eq. 1).

$$R_r = \sum_{i=1}^{N} a_i y_i + \sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij}\, y_i y_j + \cdots + \sum_{i=1}^{N} \sum_{j=1}^{N} \sum_{k=1}^{N} \sum_{l=1}^{N} a_{ijkl}\, y_i y_j y_k y_l \qquad (1)$$

Where, R: the response, Y: the influential factors and a: unknowns of the model.

Construction of the Full Factorial Design

According to (Telforda, 2007; Chlela, 2008), in order to estimate, with minimal and homogeneous uncertainty, the unknowns of the model, during the construction of the complete factorial design, we must extract from the experimental domain a sufficient number (N) of particular combinations.

Building the Model Matrix

From the experimental design, the model matrix called "effects matrix" noted X was constructed. The interactions columns were constructed by multiplying the factors between them (Goupy and Creighton.2006).

Table 2. Matrix of effects "X"

Configu-ration	Factor			Order interactions				Response
				1			2	
	F_1	F_2	F_3	F_{12}	F_{13}	F_{23}	F_{123}	
1	-1	-1	-1	+1	+1	+1	-1	R_1
2	+1	-1	-1	-1	-1	+1	+1	R_2
3	-1	+1	-1	-1	+1	-1	+1	R_3
4	+1	+1	-1	+1	-1	-1	-1	R_4
5	-1	-1	+1	+1	-1	-1	+1	R_5
6	+1	-1	+1	-1	+1	-1	-1	R_6
7	-1	+1	+1	-1	-1	+1	-1	R_7
8	+1	+1	+1	+1	+1	+1	+1	R_8

On the basis of the matrix presented in Table 2, many other matrices can be developed, such as the invariants that are given by the following relation:

$$[X'X] = \frac{1}{N}[I_N] \qquad (2)$$

Where: "X" and "X’" respectively represent the matrix of "Fisher" and its transpose matrix, "IN" the identity matrix and "N" the number of configurations.

Mathematical Processing

Each response is represented by a single configuration. The proposed approach thus leads to the following formulation:

$$\{R\} = [x]\,\{a\} \qquad (3)$$

With: {R}: response vector, [X]: calculation matrix and {a}: coefficient vector (effects of the factors and interactions).

The resolution of this system (formula 3) is carried out by means of the linear regression method, based on the criterion of least squares optimization, and which makes it possible to write:

$$\{a\} = [X^t X]^{-1}\ {}^t[X]\ \{R\} \qquad (4)$$

By inserting (2) in (4), we get the following expression:

$$\{a\} = [\tfrac{1}{N} I]^{-1t}[X]\,\{R\} = (\tfrac{1}{N})^t [X]\,\{R\} \qquad (5)$$

Results and Discussion

Structural Component Effects

Graphical Representation of Main Effects

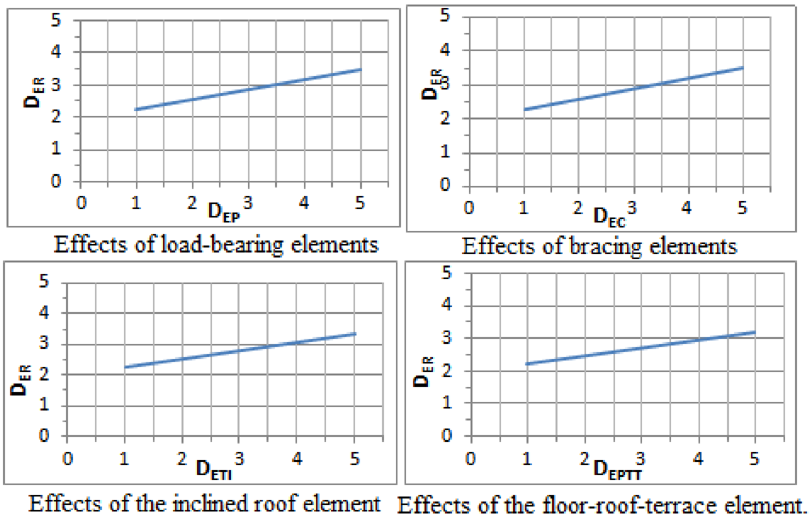


Figure 2. Graphical representation of the main effects.

Fig. 2 illustrates the effect caused by the damage of each structural component on the variation of the D_{ER} quantity, reflecting the state of their whole. Thus, the variation in the state of damage (ranging from D_1 to D_5) of each factor induces a remarkable evolution in the value of the quantity, indicating the state of damage of all the structural elements. Initially, the same degree of damage around D_2 is observed for the magnitude D_{ER} when the level of damage of each of the factors is fixed at D_1, on the other hand, a slight difference is obtained on the response D_{ER} when varying the level of damage of these same components (damage level set at D_5). We can say that two distinct degrees are recorded for D_{ER}, practically the same response around the value of 3.5 is obtained under the effect of the variation of the D_{EP} parameter and the D_{EC} parameter. Another response value of 3.15 close to level D_3 is obtained following the variation of the D_{ETI} and D_{EPTT} factors.

Graphical Representation of First Order Interactions

These so-called first-order interactions represent the capacity of a damaged component to vary the D_{ER} response under the effect of another damaged component.

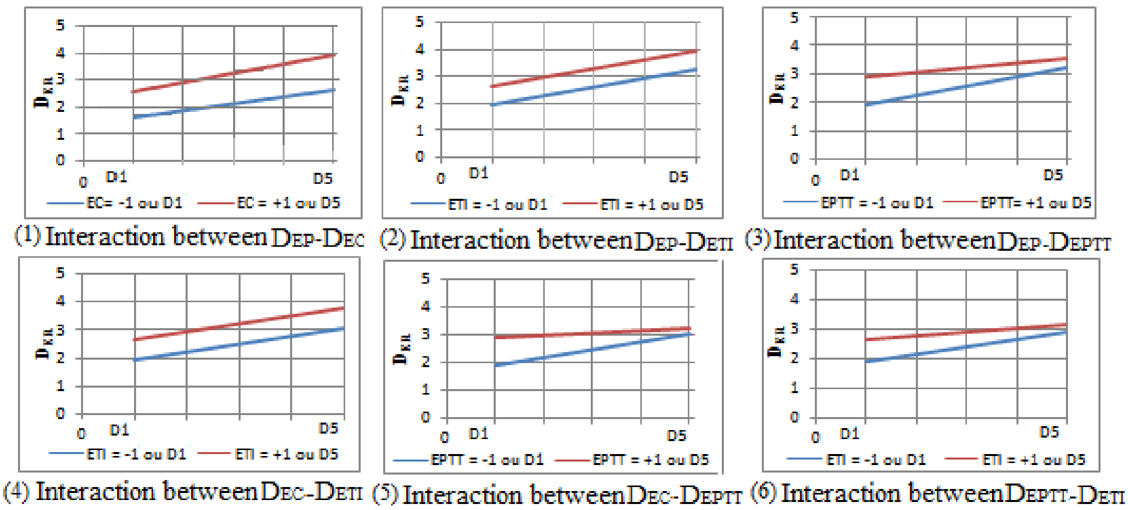
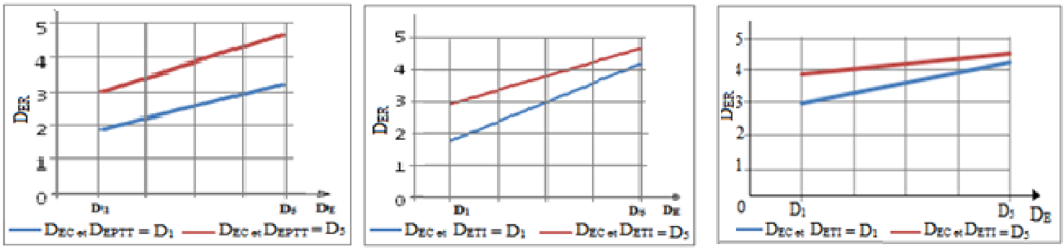


Figure 3. Graphical representation of the first order interactions of the resistant elements part.

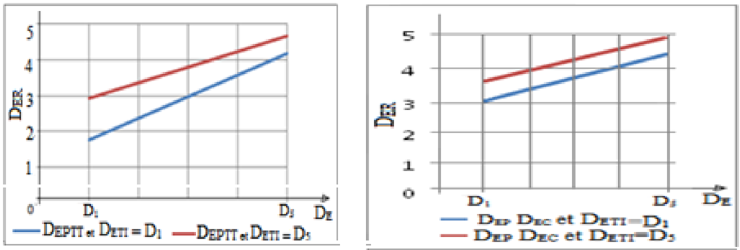
The curves given in figure 3 illustrate the different interactions, called first orders, which can exist between the four main components. Curves 1, 3, 5 and 6 expose the strong interaction that exists between the components (D_{EP} and D_{EC}), (D_{EP} and D_{EPTT}), (D_{EC} and D_{EPTT}) and (D_{EPTT} and D_{ETI}) respectively. Then, from curve 2, a weak interaction is noted between the components (D_{EP} and D_{ETI}), and another weaker one between the elements (D_{EC} and D_{ETI}) according to the results illustrated in curve 4. Also, curves 3, 5 and 6 we notice that the capacity of the mobile factor to vary the D_{ER} response decreases under the evolution of the other immobile factor (fixed at D_1 then at D_5).

Example, in curve 5, we notice that when the D_{EPTT} is fixed at D_1 (the curve in blue), the variation of the damage level D_{EC} from D_1 to D_5 induces a significant variation in the D_{ER} response. On the other hand, when the D_{EPTT} is fixed at D_5 (the curve in red), the variation of the D_{ER} response is little influenced by the variation of the D_{EC} level. While in curve 1, we see that the capacity of the mobile factor (in this case D_{EC}) to vary the response D_{ER} increases with the evolution of the other immobile factor (in this case D_{EP}).

Graphical Representation of Higher Order Interactions



(1) Interaction between D_{EP}-D_{EC}-D_{EPTT} (2) Interaction between D_{EP}-D_{EC}-D_{ETI} (3) Interaction between D_{EP}-D_{ETI}-D_{EPTT}



(4) Interaction between D_{EP}-D_{ETI}-D_{EPTT} (5) Interaction between D_{EP}-D_{ETI}-D_{EPTT}-D_{EC}

Figure 4. Graphical representation of higher order interactions for resistant elements.

Fig. 4 illustrates the interactions of orders 2 and 3 given by three and four factors respectively. Curves 1, 2, 3 and 4 demonstrate that the interactions between the different factors cannot be neglected. Thus, the shape of the straight lines of the 1st curve indicates that the effect of the variation in the level of damage of the supporting component on the quantity reflecting the state of damage of all the structural elements is practically constant, under the effect of the variation in the damage torque of the components, bracing and floor-roof-terrace, despite the evolution of the response (of a damage level), under the effect of the state of the damage torque. On the other hand, curves 2, 3 and 4 indicate that the effect of the immobile factor on the D_{ER} response varies negatively under the influence of the damage torque. Example, on the 2nd curve, we see that the category of damage attributed to the D_{ER} response under the effect of the supporting element goes from 1.5 to 4 and from 3 to 4.5, and this, when the components (bracing and inclined roof) are fixed at level D_1 and D_5 respectively. Also, from curve 5, we can say that the D_{ER} response is practically invariant after the damage of 3 components, which explains the ignorance of the damage state of the fourth element.

Effects of Non-Structural Components

Graphical Representation of Main Effects

The figure above illustrates the main effects of different factors on the D_{ENR} response. For the four factor, the same D_{ENR} response, slightly higher than level D_1, is obtained when the damage level of the element is at low level D_1. When the damage level of the element is fixed at D_5, the same D_{ENR} response, around level D_3, is obtained. Thus, the evolution of the damage level of each element (from D_1 to D_5) causes the D_{ENR} response to vary by two categories.

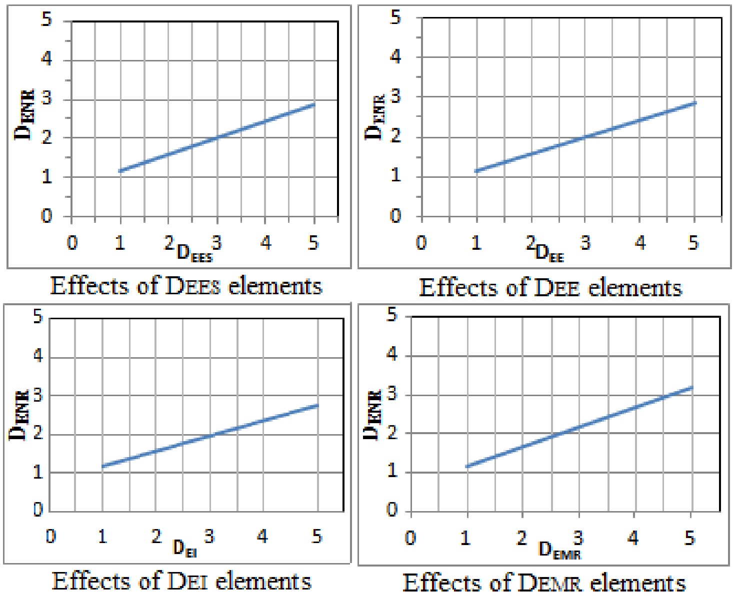


Figure 5. Graphical representation of main effects.

Graphical Representation of First Order Interactions

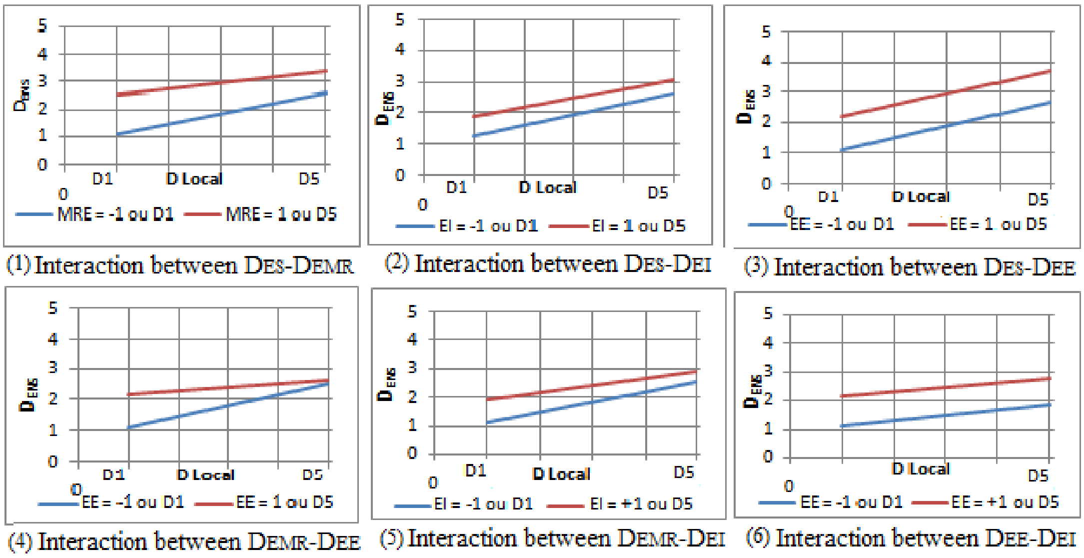


Figure 6. First order interactions of the resistant element part.

Fig. 6 illustrates the different interactions that can exist between two elements. Thus, the capacity of each element to vary the D_{ENR} response under the effect of another element is demonstrated. Referring to the shape of the lines, a strong interaction between the elements (D_{ES}-D_{EMR}, D_{EMR}-D_{EI} and D_{EMR}-$D_{EE)}$ is noted. Example, in the case of interaction (4) between D_{EMR}-D_{EE}, when the damage level of the filling wall element is fixed at D_1, the D_{ENR} response varies from 1 to 2.5 (i.e. an evolution of 150 %), under the effect of the variation in the level of damage of the exterior element (ranging from D_1 to D_5). On the other hand, when the level of damage of the filling wall element is fixed at D_5, the response D_{ENR} varies from level 2 to 2.5 (i.e. with an evolution of 50%), under the effect of the variation in the level of damage of the external element (ranging from D_1 to D_5). Also, weak interactions are observed between the elements (D_{ES}-D_{EE}, D_{ES}-D_{EI} and D_{EE}-D_{EI}). For example, in the case of interaction (3), we notice that the evolution of the response D_{ENR} under the effect of the variation of the damage level of the external element is invariable, when the damage level of the staircase element is fixed D_1 and D_5.

Graphical Representation of Higher Order Interactions

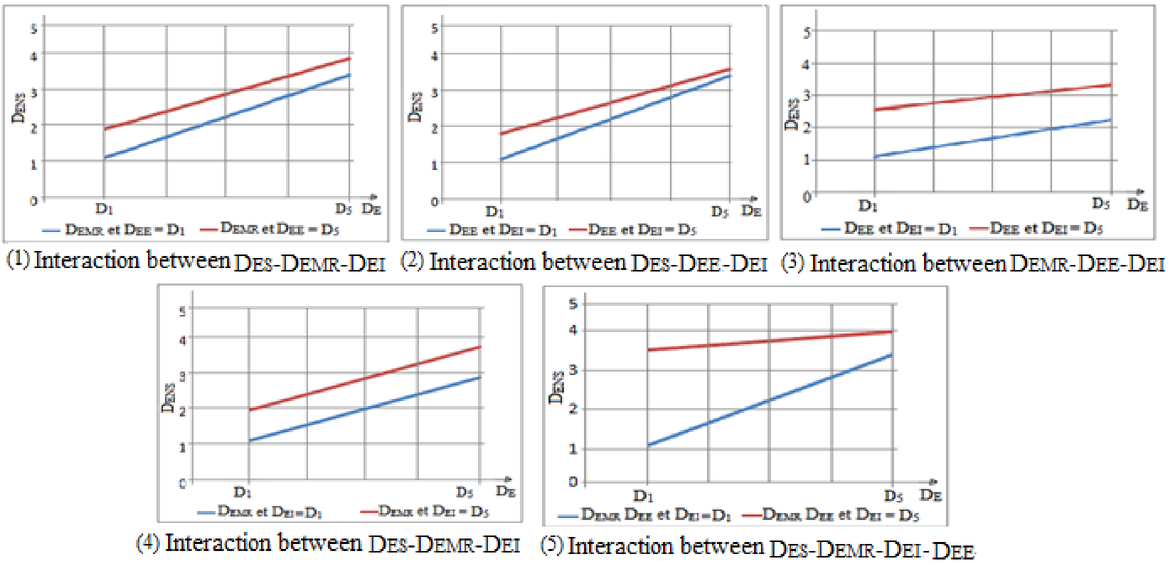


Figure 7. Graphical representation of higher order interactions, of the non-resistant elements part.

Fig. 7 illustrates the interactions of orders two and three resulting from the four non-structural elements. Curves 1 and 2 show that the same negative influence is recorded for the fixed component, under the effect of the variation in the damage torque. Example, the 1st interaction illustrates the involvement of the damage couple (D_{EMR}-D_{EE}) in the variation of effect of D_{EES} on the D_{ENR} response. For the couple (D_{EMR}-D_{EE}), the evolution from a very light damage category to another very significant one induces a reduction in the impact of D_{EES}, on the D_{ENR} response, of around 80%. On the other hand, curves 3 and 4 show that a stable effect is obtained by contributing to the variation in the level of damage of the fixed element, during the variation of the damage torque. Example, under the variation of the damage torque (ranging from a light class D_1 to a significant class D_5), the D_{ENR} varies from category D_1 to a neighboring category D_3, when D_{EES} is close to a weak damage category D_1. When D_{EES} is close to a damage category called very significant "D_5", the response varies from a degree D_2 to a level close to class D_4.

Estimation of Overall Damage

The degree of overall damage D_G is a combination of several parameters: the condition of the ground of the construction, the condition of neighboring constructions, the disorders noted on the resistant elements, the disorders noted on the non-resistant elements.

In the following part, the influence of the two parameters D_{ER} and D_{ENR} is presented:

- Of all the D_{ER} structural elements,
- All D_{ENR} secondary elements.

The approach used consists of applying, to the corpus of data, processing allowing access to a meaning that responds to the problem. This analysis can be formulated through two selection stages:

By excluding all files (structures), the final decision of which is linked to disorders appearing on the ground (PSC) and/or in adjacent constructions (PCA).

Meaning of the Coefficient Assigned to the D_{ER} factor

The overall damage varies approximately from the value 2.98 to 4.16, when the local damage (secondary element D_{ENR}) varies from a level of light damage D_1 to a level reflecting ruin D_5. Furthermore, the overall damage increases from level to while D_{ENR} varies from one important category (D_3) to another, reflecting the state of ruin (D_5). This increase of 0.57 represents the effect of the D_{ENR} factor (Fig. 8).

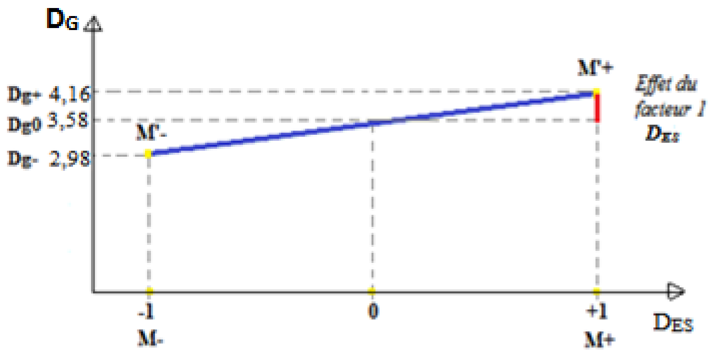


Figure 8. Representation of the effect of the D_{ENR} parameter

Signification of the Coefficient Assigned Factor D_{ER}

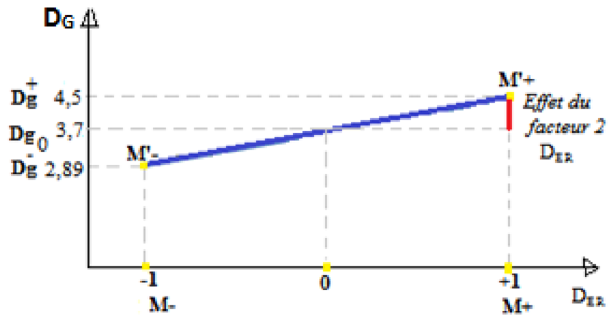


Figure 9. Representation of the effect of the D_{ER} parameter

The variation in the level of D_{ER} (from a very slight degree to a very high one) induces a "worsening" in the final decision. Indeed, the assessment evolves from a level of damage close to the so-called significant category ($2.89=D_3$) to another level close to the category indicating the state of ruin ($4.5=D_5$). On average, the D_G value changes from to, while D_{ER} varies from (D_3) to (D_5). This increase of 0.79 reflects the effect of the D_{ER} factor (Fig. 9).

Signification of Coefficient C_{21}

La The description of the relationship between the two factors consists of:

- Extract the plans ACA'C' (low level of the D_{ENR}) and BDB'D' (high level of the D_{ENR}) from figure 10, project the latter onto the same plans (Fig. 10).

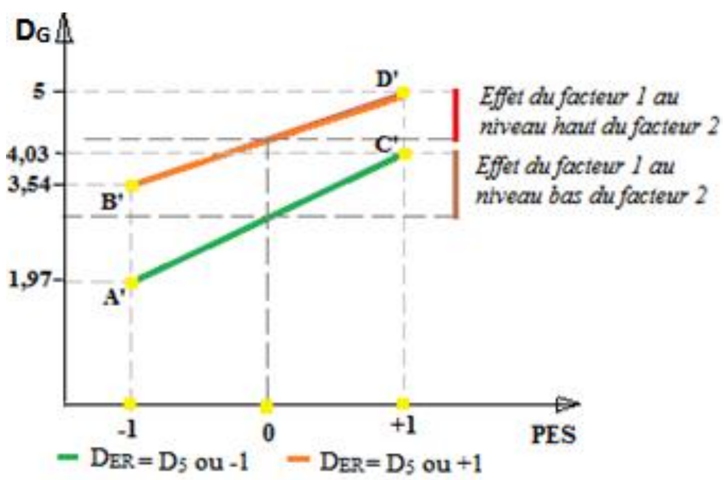


Figure 10. Illustration of the interaction between D_{ENR} and D_{ER}

Figure 10 shows the correlation between the two factors. This can be justified as follows:

- When the value of D_{ER} is close to the degree (D_1), the variation from the minimum level to the maximum level of damage for all the secondary elements induces a significant variation in the categorization of the final damage (D_G= D_2 to D_G= D_4).
- On the other hand, when D_{ER} approaches the degree (D_5), the evolution of the disorders observed on all the non-structural elements (D_1 to D_5) leads to a variation in the final classification of the construction.
- Indeed, the evolution of the D_{ER} includes an underestimation of D_{ENR}, of the order of 70%, in decision-making. The results obtained are illustrated by the equation of the proposed mathematical model. Thus, the overall response can be estimated by the equation:

$$D_G = 1 + (0.79 * D_{ER}) + (0.57 * D_{ENR}) + (- 0.107 * D_{ER} * D_{ENR}).$$

Comparison of Overall Damages

The validation of the previously proposed models is established by comparing the calculated D_G quantity to the estimated response (answer given in the sheet), on a set of ten constructions (table 3).

Table 3. The different levels of damage attributed to the components.

Construction number	Damage noted on components							
	Structural				Non-structural			
	D_{EP}	D_{EC}	D_{EPT}	D_{TI}	D_{ESC}	D_{ERE}	D_{EI}	D_{EE}
1	3	4	2	2	3	2	2	2
2	2	4	3	3	4	4	4	4
3	3	1	4	4	4	3	1	3
4	4	3	4	3	3	3	3	4
5	2	2	1	2	2	4	2	1
6	4	4	2	2	4	3	2	2
7	1	1	1	1	3	2	3	4
8	1	1	2	2	3	1	3	4
9	3	3	2	2	2	2	1	4
10	5	2	2	3	3	2	1	4

The constructions retained for the validation of the model come from the evaluation sheets which were not used in the identification procedure (establishing the models).

Table 4. Validation of the proposed model.

Construction number	Dommage global D_G		Convergence
	Estimated	Calculated	
1	4	3,88	4
2	4	4,27	4
3	4	2	2
4	4	3,70	4
5	4	3,25	3
6	3	4,06	4
7	3	3,16	3
8	2	2,99	3
9	2	3,48	3-4
10	2	3,53	3-4

Referring to the results given in table 4, it was found that for constructions No. 1, 2, 4 and 7, the model reproduces the expert's decision with an insignificant margin of error ranging from (3% to 7.5%). Whereas, for constructions No. 5 and 6 the model converges on the experimental with a percentage difference ranging from (18.7% to 26.1%), i.e. an inaccuracy of ±1 degree of damage. On the other hand, the greatest difference is observed on constructions No. 3, 8, 9 and 10. This divergence of 33.1% to 50% testifies to the importance of imprecision, i.e. an error of ± (2 or 3) degrees of damage.

Although the same category of damage (very significant) was attributed to the first 05 constructions (Table 4), a significant difference is noted in the level of damage noted on the various elements (Table 3). For example, the same decision was taken for the 1st and 5th construction (regarding the maintenance or cessation of operation). Whereas, in the detail of the inspection, a shift of 20% in terms of the extent of damage was recorded on the 1st construction compared to the 5th.

Conclusions

In this part three models have been developed, each specifying a particular point:

- The state of all the elements constituting the secondary structure called D_{ENR}.
- The state of all the elements making up the resistant structure called D_{ER}.
- A categorization of the overall state of the construction.

On the basis of the results obtained, and in the case where the damage is observed only on one of the groups of components, we can propose that the expert's decision-making is based on:

- 80% on the situation of the resistant structure, when the damage is noted on this group of elements.
- 50% on the situation of the secondary structure, when the damage is noted on this group of elements.

Affecting both subgroups implies an underestimate of their respective effects in decision-making, because economic considerations must also be taken into account.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

Funding

* This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgements or Notes

* This article was presented as a poster presentation at the International Conference on Technology, Engineering and Science (www.icontes.net) held in Antalya/Türkiye on November 12-15, 2025.

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Author(s) Information

Akkouche Karim
Mouloud Mammeri University of Tizi-Ouzou, Department of Civil Engineering, Tizi-Ouzou, 15000, Algeria
Contact e-mail: *karim.akkouche@ummto.dz*

Khelil Nacim
Mouloud Mammeri University of Tizi-Ouzou, Department of Civil Engineering, Tizi-Ouzou, 15000, Algeria

Nekmouche Aghiles
Mouloud Mammeri University of Tizi-Ouzou, Department of Civil Engineering, Tizi-Ouzou, 15000, Algeria

Kahil Amar
Mouloud Mammeri University of Tizi-Ouzou, Department of Civil Engineering, Tizi-Ouzou, 15000, Algeria

Hamizi Mohand
Mouloud Mammeri University of Tizi-Ouzou, Department of Civil Engineering, Tizi-Ouzou, 15000, Algeria

Bouzid Leyla
Mouloud Mammeri University of Tizi-Ouzou, Department of Civil Engineering, Tizi-Ouzou, 15000, Algeria

Atlaoui Djamel
Mouloud Mammeri University of Tizi-Ouzou, Department of Civil Engineering,Tizi-Ouzou, 15000, Algeria

To cite this article:

Karim, A., Nacim, K., Aghiles, N., Amar, K., Mohand, H., Leyla, B., & Djamel, A. (2025). Development of a relation model for damage categorization**.** *The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM), 38,* 69-80.