SELECT.FC: A NEW APP TO SELECT AND EVALUATE FRAGILITY CURVES FOR SEISMIC RISK STUDIES

RESEARCH GROUP ON SEISMIC RISK
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## Introduction: The importance of selecting an appropiate fragility curve

- To quantify the human and economic losses caused by earthquakes, seismic risk studies generally use **fragility curves (FCs).**
- The appropriate FC allows a better approximation of the level of performance of a structural system in the face of seismic hazards. **An inadequate selection of the FC can mean a notably unreliable estimation of damages and losses.**
- This research proposes an innovative application called "Select.FC", designed to implement a new methodology for assessing and selecting FCs for seismic risk studies from a catalogue of existing proposals available.

Methodology

This new methodology allows the **classification of FC** based on a **multidimensional index**, considering a set of relevant variables associated with various aspects of the curves and classified into **3 main dimensions**:

1) The **Technical suitability** of the FC dimension, with 3 sub-dimensions: Capacity, Fragility, and Quality, includes various variables that allow for a comprehensive evaluation of the capacity curve, fragility curve and quality of the study that proposes de curves.

2) The **Suitability for the local system** dimension evaluates the degree to which the FCs are appropriate for the local context.

3) The **Building class similarity** dimension evaluates the similarity between the building types of the candidate functions and that of the region under study by considering the quantity and nature of their attributes in common.
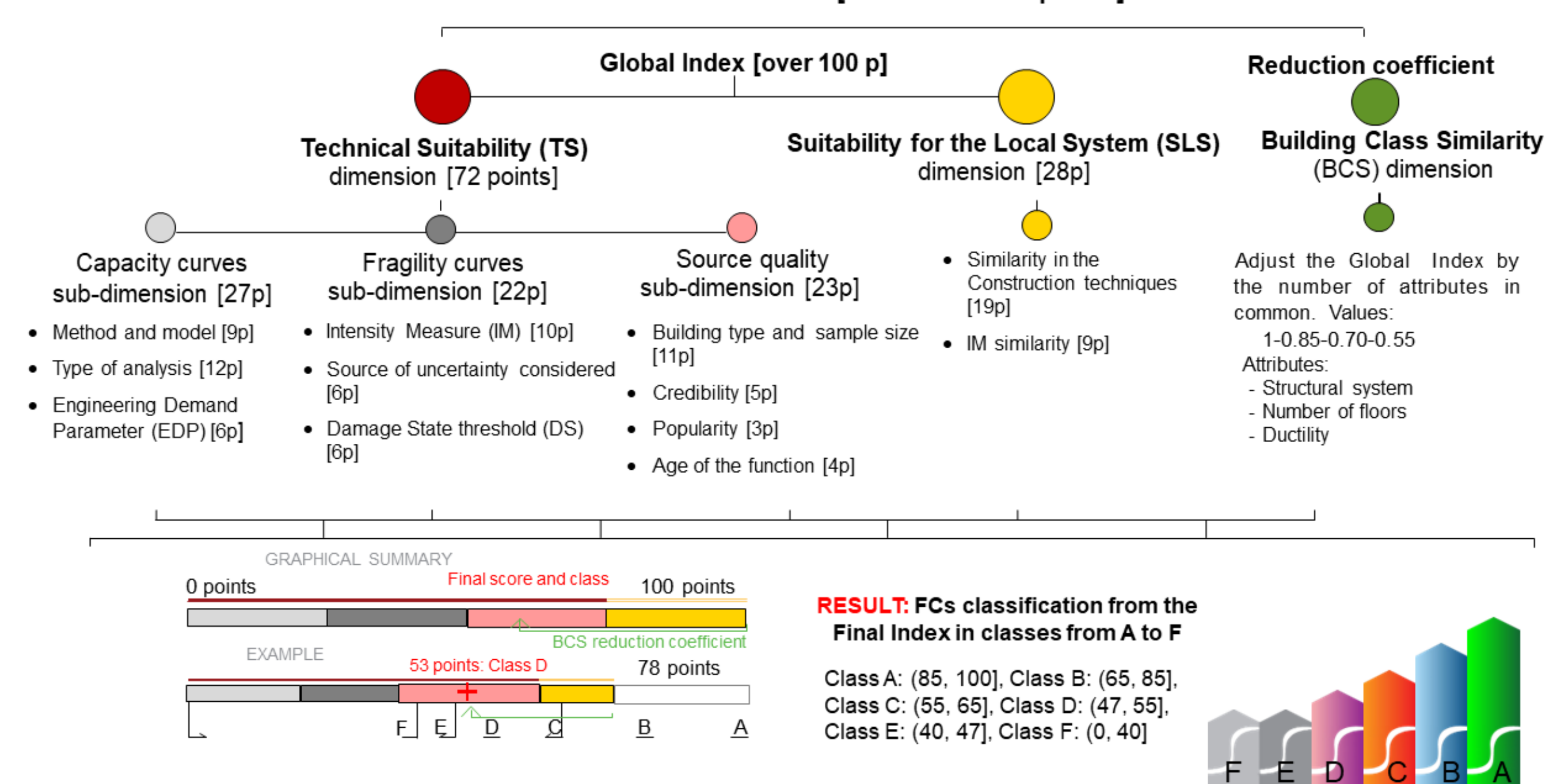
The bottom of Figure 1 shows a graphical summary (in the form of a horizontal bar) of the importance of each sub-dimension and dimension involved, along with an example. In the example, the Global Index (Technical Suitability + Suitability for the Local System) sums up 78 points. The maximum score an FC can obtain in each index, dimension, sub-dimension, and variable is indicated in brackets. The score of each of the 2 mentioned dimensions is the add of scores of the variables involved. The reduction coefficient (green arrow) reduces the Global Index to the Final Index. This Final Index determines the class of the FC assessed (from A-best to F-worst). Therefore, the FC used as an example is class D.
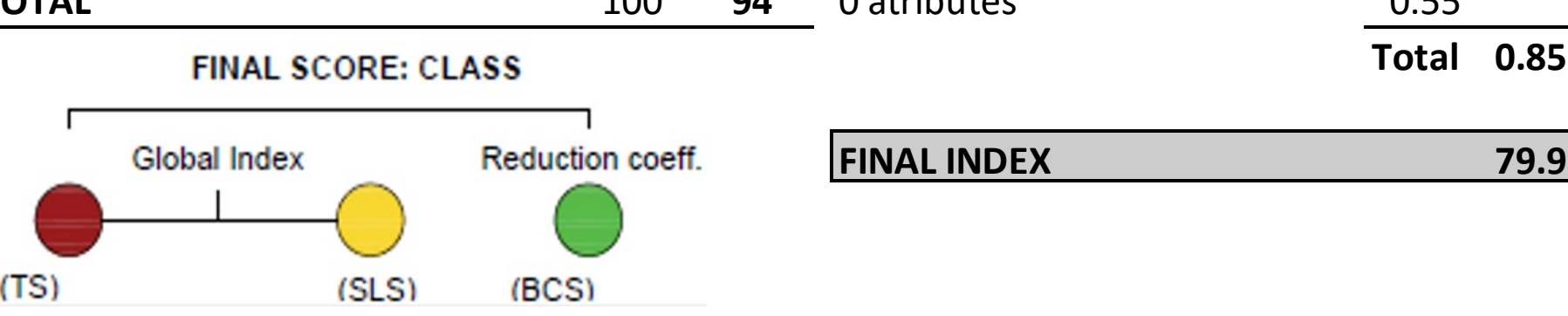
International Expert Survey and Fuzzy Analysis

- A **calibration and validation process** was conducted on the **variable scores** of the **multidimensional index proposed.**
- The calibration process involves a **worldwide survey of experts** in seismic vulnerability.
- The **fuzzy analytic hierarchy process (FAHP)** method was employed to calculate the fuzzy scores or weights based on the survey responses of the experts, leading to more objective and dependable scores.

Example

TECHNICAL SUITABILITY SUBINDEX (72 p.)

Subdimension	Score	FC	Subdimension	Score	FC	Subdimension	Score	FC
CAPACITY CURVES	**27**		**FRAGILITY CURVES**	**22**		**QUALITY**	**23**	
Method and model	9		**Intensity measure (IM)**	10		**Building type and sample size**	11	
Experimental 3D	9	X	EB>10 and PR probabilistic	11	X	EB>10 and PR probabilistic	11	X
Experimental 2D	7	X	Spectral displacement (Sd)	8		PR and Sample=1	9	
Analytical 3D	5		Peak ground acceleration (PGA)	6		EB and Sample=5-10	6	
Analytical 2D	4		Discrete IM (MMI, EMS-98)	0		EB and Sample=1-5	4	
SDoF combinada (GEM)	2		**Source of uncertainty considered**	6	X	EB and Sample=1	0	
SDoF	0		3 sources considered	6	X	**Authenticity and Credibility**	5	
Type of analysis	12		1 or 2 sources considered	4		High	5	X
Nonlinear dynamic analysis (NLD)	12	X	No source considered	0		Medium	3	
Nonlinear static analysis	6		**Damage State thresholds**	6		Low	0	
Simple	0		Customised	6	X	**Popularity** (citations)	3	
EDP	6		Preset	0		High (50+ Big source data)	3	
Inter-story Drift Ratio (IDR)	6	X		**Total**	**22**		Medium (10- 50)	1	
IDR global	6						Low (<10)	0	X
Maximum displacement	3					**Age of function**	4	
Roof displacement	0					<3 years	5	
	Total	**25**				3-5 years	3	X
						5-10 years	3	
						10-20 years	1	
						older	0	
							Total	**19**

SUITABILITY FOR THE LOCAL SYSTEM SUBINDEX (28 p.)		
Dimension	Score	FC
Similarity in Construction techniques	**19**	
Country	19	X
Subregion	14	
Region	10	
Out of the region	0	
IM similarity	**9**	
High, equal IM	9	X
Medium, different IM	5	
Low	0	
	Total	**28**

GLOBAL INDEX		
Dimension	Score	FC
Technical suitability	**72**	**66**
Suitability for the local system	**28**	**28**
TOTAL	**100**	**94**

FINAL SCORE: CLASS

| ADJUSTMENT COEF. BY BUILDING CLASS SIMILARITY		
Number of common	Score	FC
3 or more attributes	1.00	
2 attributes	0.85	X
1 atribute	0.70	
0 atributes	0.55	
	Total	**0.85**

FINAL INDEX	79.9

Select.FC App

This **new application** in development **automates** the **proposed methodology** to **evaluate and classify fragility curves** for a given typology.

Application feature and interface

① **Start of Process**: To begin the evaluation of FCs, select the "**Evaluar**" option from the options menu available in the web application.

② **Filtering of fragility curves**:
- **6 filters** will be presented on the screen to search for FCs in our database, **2 filters are required**: "Materials" and "Height Range" and they show a default option. However, the user can adjust these selections according to their needs.
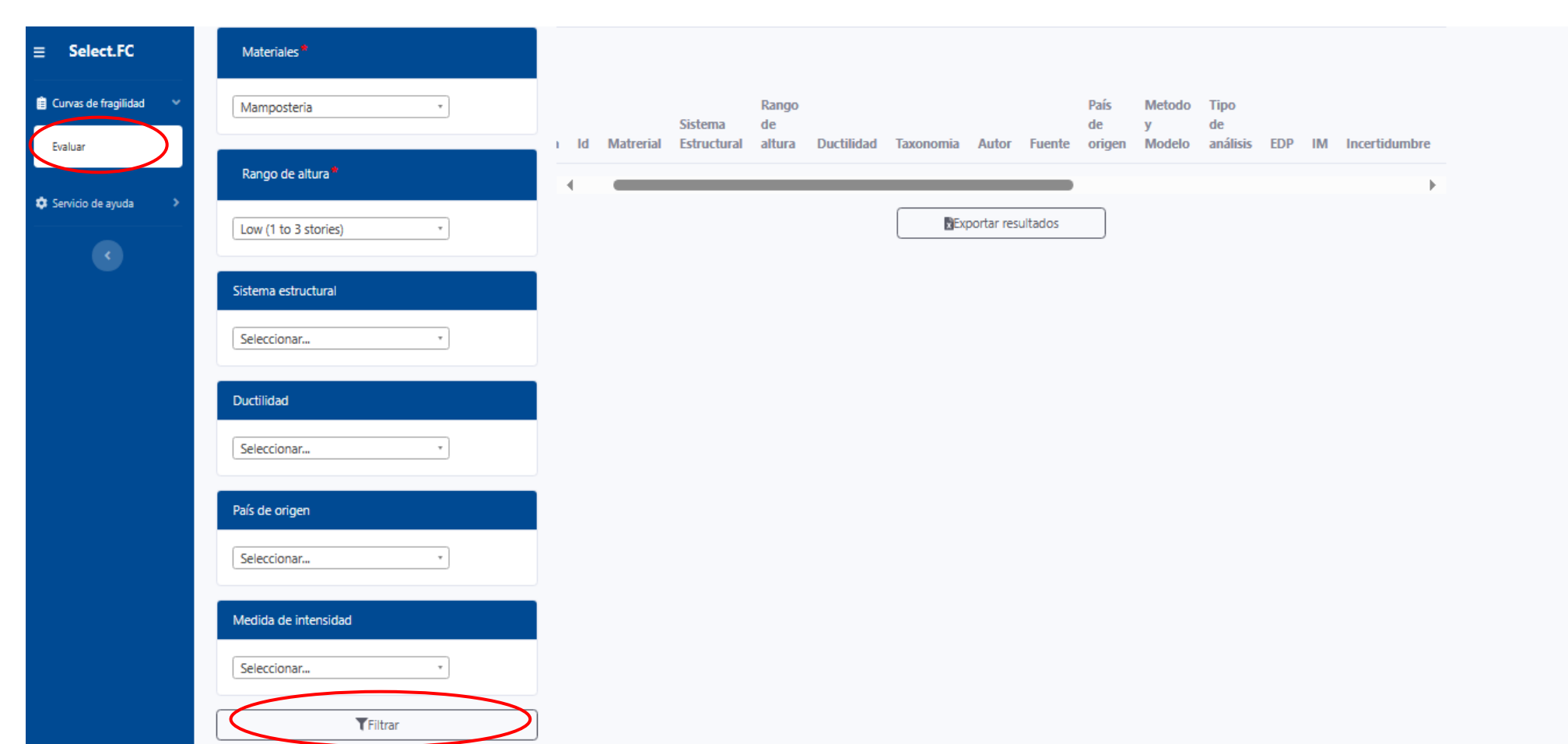
- The **4 remaining filters**, "Structural system," "Ductility," "Country of origin," and "Intensity measurement," **are optional** and can be selected according to the user's preference.
- After adjusting the filters, click the "**Filtrar**" button to see the results corresponding to that selection.

③ **Start of evaluation**:
- The screen will display all the results that correspond to the selection the user previously made.
- To start the evaluation process, click on the green button with the "+" symbol for each of the curves successively.
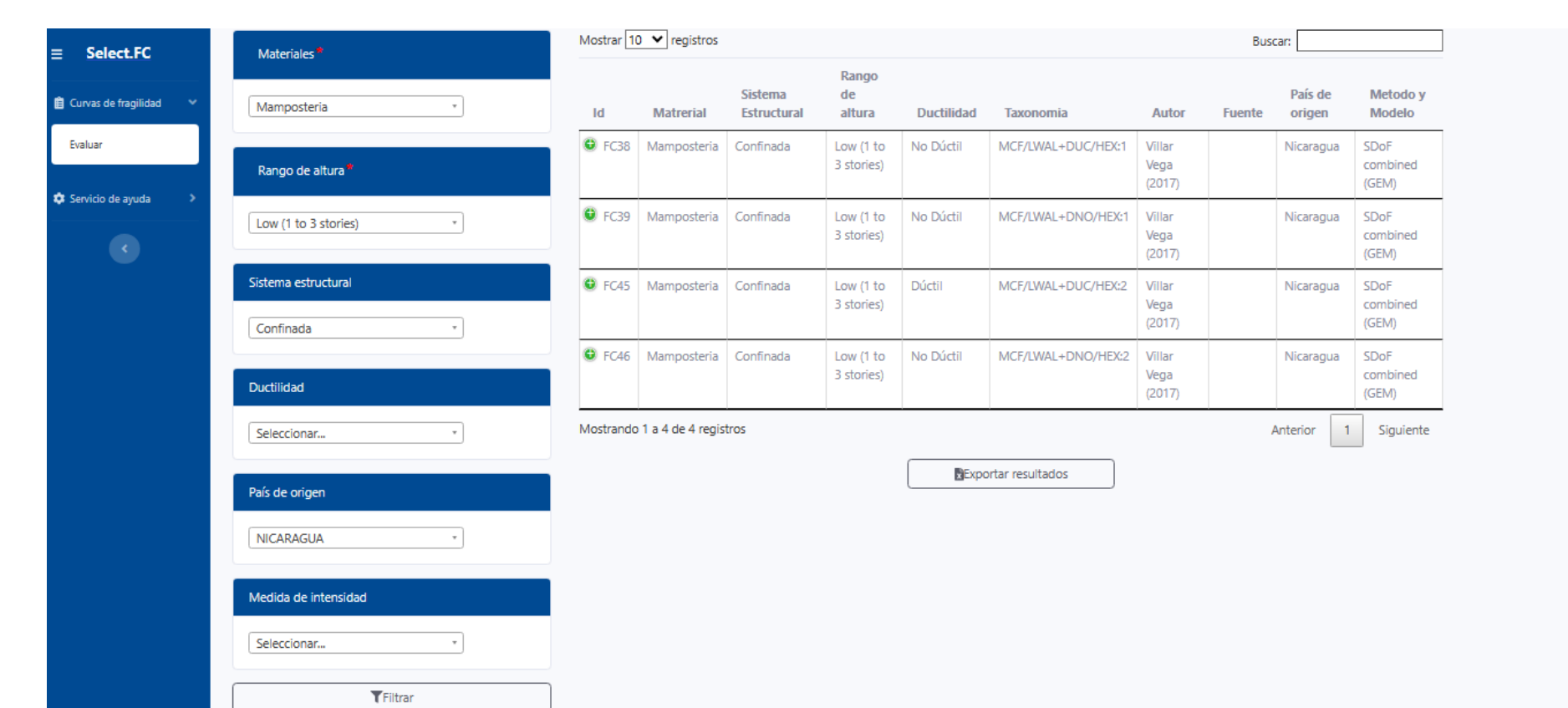
④ **Classification of curves**:
- Select the blue button with the pencil symbol to evaluate the selected curve. A screen will appear with the parameters of the FC's "Technical suitability" dimension, inherent to the curve itself and not dependent on the specific seismic risk study for which you want to use it. Three additional fields will also appear: two from the dimension "Suitability for the local System" and the reductor coefficient "Building class similarity." The user must select the options that best fit their study and click "Save."
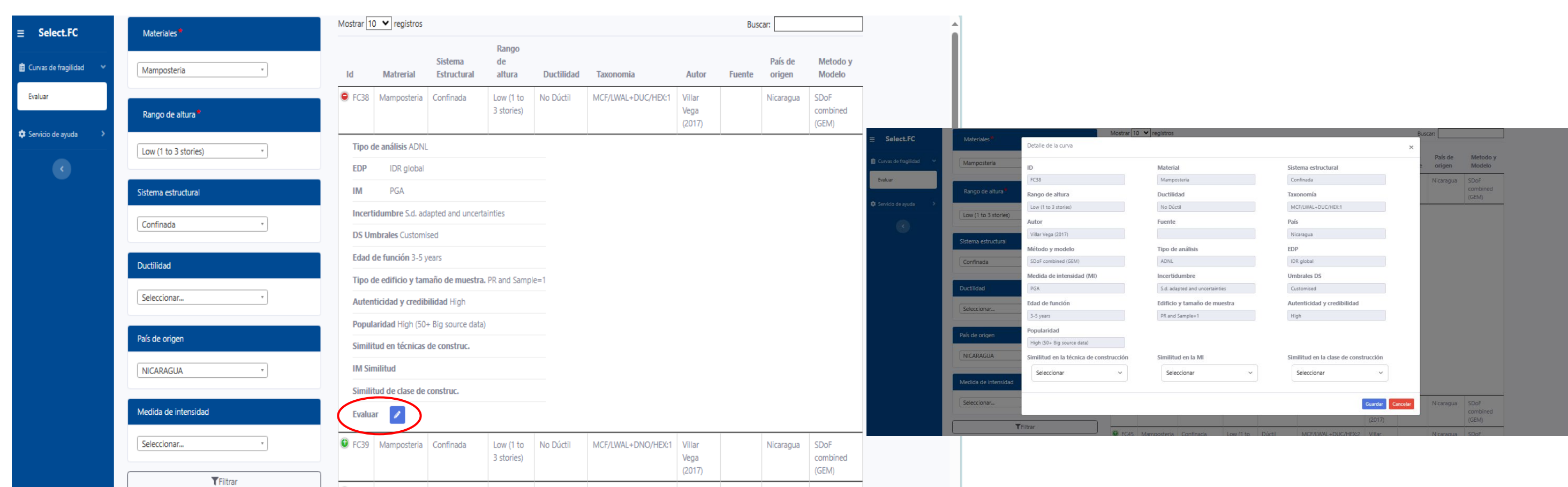
⑤ **Export of results**:
- Once the evaluation of all curves is completed, click the "Export Results" button to obtain the results. This command will download an Excel file with the name "Fragility Curves Evaluation".

Example of the data proportionated by Excel fie

Try the app by scanning the QR code

Conclusions

- The **proposed methodology** permits evaluate the **reliability level of the FC** depending on the class the curve was classified into because of its score. The proposed index can be broken down into its **three dimensions and component variables**, allowing the researcher to recognize those the FC's strengths and waknesses.
- This **initial version of Select.FC App** includes a comprehensive database of Central America FCs with their parameters and evaluated variables. The proposed classification system allows identifying the most appropriate FC for the main construction typologies in Central America.
- **Future plans for Select.FC App** include:
- **Allowing the users to add their FCs** for automatic scoring and ranking.
- Making the app part of an **open-source platform** for comprehensive and more accurate assessment of seismic risk.

- **Reference for further detail:**
Navas-Sánchez, L., Jiménez-Martínez, M., González-Rodrigo, B., Hernández-Rubio, O., Dávila-Migoya, L. D., Orta-Rial, B., & Hidalgo-Leiva, D. (2023). **A methodology to assess and select seismic fragility curves: Application to the case of Costa Rica**. *Earthquake Spectra*, 39(3), 1380-1409.