Residential Buildings Fire Safety Application for iPhone / iPad Devices

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Abstract

This paper describes the processes followed for the creation of a fire safety application for iPhone/iPad devices, which, for educational reasons, has produced R&D and is applicable to professional practice, and is based on two, apparently unconnected points: 1. University teaching, research and the professional practice of architecture should not be unconnected activities, but the complex reality of the world of construction means that they are seen as separate. / 2. It is obvious that many technological tools such as PC tablets, smartphones… are being used by the general public in their everyday lives.

With these precedents, the aim of the project was to create a software program so that a student, lecturer or professional architect could, at any time or any place, use the tool to calculate the main fire safety parameters for a residential building (number of sectors, occupation, structure resistance and dimensions of the evacuation routes) obtaining a result which, beyond regional or national regulations, assesses the appropriateness of the proposal.

Thus, based on the Spanish norms, and with reference to the Performance Based Design so as to be applicable to any project, we have a simple software program which returns the mentioned parameters with the input of only six pieces of data on the building.

1. Introduction

The complex task of developing an architectural project means making calculations that lead to a final result. For example, in the case of the sanitary installations in a building, the indications in the regulations must be followed and, based on the sanitary fittings in the building and their corresponding flush units, a series of results is obtained, such as the diameter of the down-pipes. Likewise, a similar process is followed for other areas of a building such as thrash management, water supplies, structures… and fire safety.

Moreover, we see that the origin of the development of this software is part of the Fifth Year subject Building Services Design, where the architectural students must, in a very short time, find the main values for everything to do with fire safety elements in the projects they design.

All of this makes up the objective of the app which assists with the design requirements for fire safety in a residential building. Although the Spanish regulations in Basic Document CTE-DB-SI

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are used as its basis, the essence of the app is not to fulfill any particular regulations, but to provide a rule of thumb which, for the first sketches of the building design, would allow one to see how close the creation of a safe building was from this perspective; a tool that brings teaching and professional practice together in such a way as to be within the reach of anyone anywhere.

With this tool we can determine the occupation density, the number of exits per floor, the maximum evacuation distance and the sizing of the main evacuations means (doors, corridors, landings and staircases).

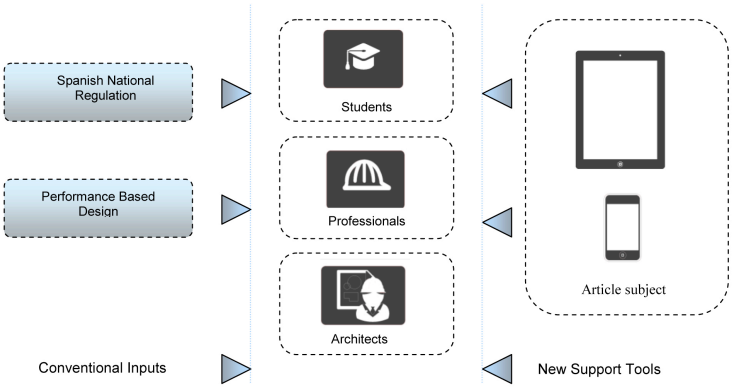

Figure 1. Graphical abstract.

2. Methodology

The creation process for the app was the following:

- Deciding on the safety parameters demanded by the regulations.
- Comparing these values with those which, thanks to professional experience and architectural repercussions (e.g. the position of the staircases), are of immense importance for building students and professionals.
- Creating the calculation engine on an Excel spreadsheet.
- Design of the graphical interface.
- For the AutoSum of points 3 and 4, the programming was carried out in Apple XCode (Objective-C).
- Several Beta versions were created and distributed among students, professors, architects, engineers and administration professionals to get feedback and improve the app before its definitive publication on the online App Store.

3. Calculation engine

The calculation engine for this app is based on the requirements of Section SI 3 for the evacuation of occupants of the Spanish Building Technical Code (CTE), in line with the following list:

- The occupation number is determined depending on the use of the building[1].
- The number of exits per floor is determined and depends on the occupation numbers, the use of the building, the route length and whether there are automatic fire-extinguishing systems.
- The sizing of the means of evacuation is carried out.
- The degree of safety of the staircase of the building is determined.

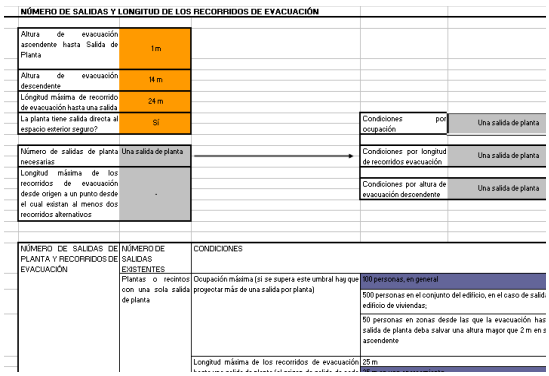

Fig 2. Calculation screen display.

Next, the development of the calculations used is described:

- Occupation density is calculated with the quotient of the building surface divided by its occupation in persons/ m2. For a residential dwelling 20 m2/person is used.
- The number of exits per floor and the evacuation distances are calculated. To do this, we must analyze the conditions fulfilled by the occupation, by the length of evacuation routes and the conditions by height of the downward evacuation.[2]. Regarding the conditions by length of evacuation routes when only one exit per floor is available, the evacuation routes do not exceed 35 m for this type of use. Likewise, the length of the evacuation routes from the starting-point to a point where there are at least two alternative paths does not exceed 35 m. In the case of the existence of an automatic fire-extinguishing system, said routes may be increased by 25%.
- With reference to the conditions by height of the downward evacuation, buildings with an evacuation height of over 28 m will have more than one exit per floor. In this case and if over 50 persons have to climb over 2 m, then two exits per floor lead to two different staircases.
- The width of the doors and landings is calculated using the formula Width ≥ People /200 where People is the total number or persons anticipated to pass by the point whose width is measured. This must not be less than 0.80 m nor over 1.23 m. The measurements consider than no door leaf must measure less than 0.60 m.
- For corridors and ramps, the formula above is again used. However, in this case the minimum width is 1.00 m.
- Regarding the staircases, we allow for three different types: non-protected staircases, protected staircases and specially protected staircases. If the building has a downward evacuation height of less or equal to 14 m, the stairway does not need protection. If said height is less or equal to 28 m, the stairway shall be protected, and in the case of a downward evacuation of over 28 m a specially protected stairway is necessary.
    - Referring to non-protected stairs, the calculations differ depending on whether the evacuation is upward or downward. In the former, the formula is: Width ≥ People/ (160-10h) where h is the upward evacuation. For downward evacuation the formula is: Width ≥ People /160. For this type of stairs, the minimum width is 1.00 m.
    - For protected stairs[3], the formula used is: Width = (E – 3 S) /160 where E is the sum of the occupants assigned to the stairway on the floor taking into account the floors below or above going towards the exit from the building, depending on whether the evacuation is downward or upward, respectively, and S is the used surface area of the space or of the protected stairway within the whole of the floors from which E comes.

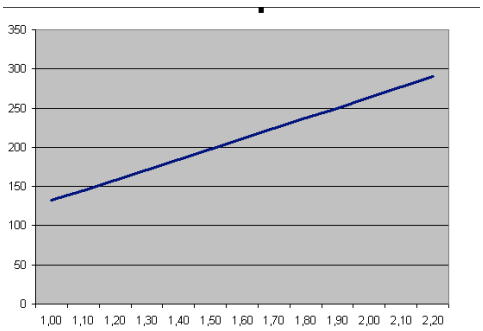

Table 1. Graphical relationship between staircase width and person occupation. Upward evacuation.

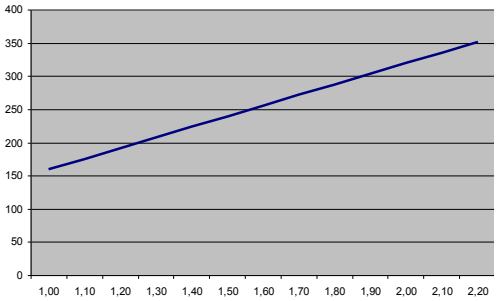

Table 2. Graphical relationship between staircase width and person occupation. Downward evacuation.

4. Software development

For this app, moving the values from the spreadsheet to program in XCode format was relatively simple, it meant ‘just a few’ hours work, although the same cannot be said of the following points.

4.1. Screen design

This is the first app developed by the University of Navarra, specifically in its School of Architecture, where the formal and aesthetic requirements are of great importance.

Moreover, concurrently with the production of this app, another three were in the works, so the concept of the collection of apps also had to be resolved in this first app.

Hence, the seemingly simple user interface was complex to design, as it had to be the basis for this app and for other future apps (yet to be designed at the time), either by the School of Architecture or other Schools.

Moreover, the production of two different formats was considered appropriate, one for iPhone/iPod and another for iPad, which meant two-fold programming so as to optimize the resolution on both devices.

In terms of spread of knowledge, fundamental in a university environment, its publication in Spanish, English and Chinese was considered worthwhile and non-problematical.

Fig 3. iPad calculation screen (Chinese in this case).

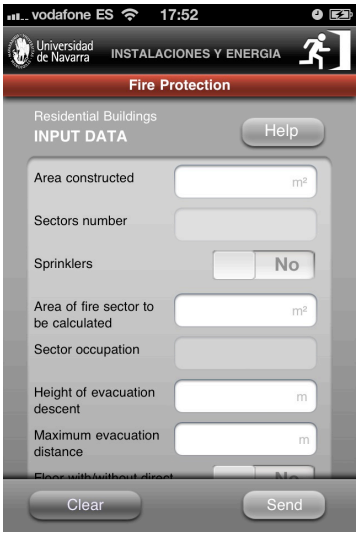

Fig. 4. iPhone calculation screen (English in this case)

4.2. Validation

Obviously, a tool like this which, once published, did not fulfill its initial objectives of user friendliness and speed of calculation, would be useless. So the process of validation of the app by students, professors and architects was of great importance before its definitive publication.

In this process, seven different beta versions were created and delivered numerous suggestions for improvement concerning legibility, calculation criteria and the screening of results.

An online survey was also carried out among the beta testers so they could give a numerical opinion on the different elements.

4.3. Management

The help screen is quite simple, as it merely shows text; however it was one of the major snags, as it had to explain in legal terms that it is a tool for assistance, that is to say, its results can never justify the complete development of a project.

This detail, with the large potential audience of the app as it is produced in Spanish, English and Chinese, required many hours work by the University legal teams, and we mention this here, as over and above the research and work involved in the article, it is an issue of importance for other researchers who will develop apps in university areas.

5. Discussion

As far as the authors know, this is the first app of its kind produced by a School of Architecture. Thus, the doubts and problems resolved were not difficult in themselves, but were complicated because they had never been dealt with before.

The following gives a general list of the team's reservations:

- As this app is produced at a School of Architecture, another objective which is also important, is to encourage the students to be familiar with the regulation norms and thus to apply them to their future professional projects.
- As it was created at the University, a query that was repeated again and again from the start was whether the app should be free, or sold at a token price, or if enough should be charged to cover the costs (in this case about €5,000), thereby earning funds for future applications. Finally, it was decided to charge €0.79.
- The aesthetics of the app, with several architects among its beta testers, was at times an additional problem, but the final result is even better than expected in two ways: the usability of the app and the creation of the collection aesthetics needed for later apps.
- Should the app be developed for the Apple system only or also for other devices such as Android? Obviously the app promoters would have preferred the app were developed for both platforms, but it was a cash-flow issue: there wasn't enough for the two. Apple was chosen because it is more widespread in Spain in the construction field.
- From the beginning, one of the main objectives was that the app had to be speedy, clear and easy-to-handle on a single screen[4]. With this in mind, many arguments focused on what the inputs and outputs of the app should be and, over and above legal norms and requirements, the authors' experience was decisive in defining this applied research.

6. Conclusion

With the process finished and the app published, our conclusions can be summed up as follows:

- The availability of the app in several languages has confirmed how easily it has become well-known among the specialist public.

- It would be desirable that apps produced by the University as a means of spreading knowledge should be distributed free of charge. Even though the cost of our app is very low, the price may be a handicap for its spread among students.
- Apart from the usual spread of academic knowledge in indexed journals and specialized congresses, there is no doubt that apps for these devices will be important in the future, and their implementation will have to be resolved, as evidently they cannot be patented nor are they controlled by peer-to-peer revision, but may become very widespread among academics and professionals[5].
- This software was developed for iPhone and iPad devices by construction professionals (students, architects, engineers and administrative staff) in Spain. The software could also be developed for Windows, Linux or Android interfaces, which is simple as the problem is not the language programming, but the creation of the original calculation engine.

Acknowledgements

Juan Echeverría. PhD Architect.
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Guillermo Pérez. Architect.
David Bayón. Engineer.

References

[1] Martín-Gómez C, Mambrilla N. *El dónde y el cuándo de la investigación en Protección contra Incendios*. 4th International Meeting on Architectural and Urbanism Research, Valencia, Spain. 1, 2, 3 June.

[2] CTE, Código Técnico de la Edificación, Technical Building Code.

[3] W. Jahn, G. Rein, J.L. Torero. *Advances in Engineering Software*

[4] N. Ryder, J. Sutula, C. Schemel, A. Hamer, V. Van Brunt. *Consequence modeling using the fire dynamics simulator.*

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[1] Annex SI A, CTE. Different uses: Residential dwelling, Public residential, Parking, Administrative, Teaching, Hospital, Business, Public Audience and Archive, Warehouses.)

[2] See, for example, for a floor to have only one exit, the ocupation for this use must not be over 500 persons for the whole building, or over 50 if a height of over 2m upwards must be tackled.

[3] In accordance with the CTE, this is a continuous staircase from its start to its foot on the building exit floor which, in the case of fire, forms a sufficiently safe place where the occupants can remain for a certain time. The remaining conditions can be found at <www.codigotecnico.org>

[4] See, for example, the apps developed by the American Society of Heating and Refrigeration American Engineers ASHRAE.

[5] In barely three monts the app has been downloaded in China, USA, Panama, Argentina, Guatemala… places where the promotors of this app might not have reached with the usual means of spreading knowledge.