LEARNING BASIC PRINCIPLES OF FIRE REGULATIONS

An experimental teaching and learning tool

MOHAMED RASHID EMBI AND MALSIAH HAMID Department of Architecture
Universiti Teknologi Malaysia
Skudai, Johor Bahru
Malaysia
b-rashid@utm.my
malsiah@utm.my

AND

AHMAD RAFI M.E
Multimedia University
Malaysia
ahmadrafi.eshaq@mmu.edu.my

Abstract. The study on integrating fire regulations into the design process is described through several study and analysis. However not all of them address the real issue of which fire regulation are difficult to be considered at the early stage of the design process. There are few factors on which fire regulation was not being considered at the early stage of the design. Two strong factors are the complexity of the regulations and the lack of knowledge among architects about fire regulations. Therefore fire requirements are always considered towards the end of the design process. This paper intends to address about the issue of difficulties in fire regulations and how we think these can be solve. We also design a system that can be used either by students or architects to understand the principles of the regulations and its applications in the design process. Finally a prototype system is demonstrated on how we envisage the system that can be used to help architects integrate fire regulations at the early stage of design process.

1. Introduction

Architectural design is a complex design process. Architects have to consider all aspects of design and solve all design problems at the same time. They also have to comply with various building laws relating to energy consumption, natural lighting and ventilation requirements, sewerage including **building fire regulations**.

Fire regulations have been imposed in order to ensure that buildings and their occupants will be safe from the hazard of fire. Therefore, architects must ensure that their design complies with the regulations. However, the main difficulty is that architects are unable to integrate the fire regulations requirements into the early stage of the design process. This is due to two factors: *first*, the nature of fire regulations that are very stringent, complex, require interpretation and are difficult to understand. It also requires the design to be almost complete in order to know what is required and whether the design has satisfied the rules. *Second*, because of the unique nature of the architectural design process. Architectural design generally begins with 'vague' ideas; it develops from an 'ill-defined' to a more complete and precise design scheme, whereas fire regulations have been prescribed in detail.

Based on the first factor, we designed a prototype system to help learning the fire regulations.

2. Computer Aided Design

Having outlined the issues and the problems, the second task of the work is to study how a computer can be used to help architects with the design. In particular how a computer can be utilized to help architects consider and integrate fire regulations in the design process.

The use of the computer in architectural design has been very successful especially for the production of drawings, rendering and animation. Current technology has allowed the operation to be much more complex and faster. The use of the computer in architectural design can be simply descriptive: solely for drafting what has already been designed (Radford, 1991) . The next popular use of computers in design was for prediction. The predictive systems are more commonly regarded as those that predict non-visual performance characteristics of the built environment through the operation of mathematical modelling. This can be, for example, prediction of structural behaviour, prediction of energy use or prediction of cost feasibility. Probably the most cited example in architecture is space planning. All these prediction systems will require a description of the geometry and other relevant attributes of the proposed design. In other words, architects must first produce or finish the design before the prediction can be performed.

Our interest is in how the computer could be used to help architects learn about fire regulation and help them regarding fire regulations during the early stages of the design process. Thus, with this general understanding of the current role of the computer in design, we want to explore how a computer could be used to help architects to consider fire regulations in the early stage of the design process.

3. Building Regulations

It is clear that the function of building regulations is to ensure that a certain standard of safety for the occupants and the building (property) is achieved by the architects' design.

It clearly shows that the development of building regulations was intended to control the design of the building more rigorously, even though the authority meant this for ensuring and maintaining higher standards of safety for the public. It has been argued that building controls are oppressive and unnecessarily detailed, difficult to enforce and open to abuse of power by the authorities and by the courts and to misuse by the client (Short, 1982) .

Harper has argued that building regulations have had a negative effect on the freedom of the architectural design process (Harper, 1977). It has also been argued that it can cause two unhealthy side effects—the mandatory requirements and the quantitative requirements which can dominate the architects' thinking (Lawson, 1975). Thus the nature of building regulations: complex, ambiguous, uncertain, etc., has caused conflict with the nature of the architectural design process. Many writers have made the criticism that building regulations are not a tool to be used in the design process (Lawson, 1975 & 1982; Allen, 1987; Stollard & Abrahamas, 1995).

Due to its complexity, the building regulations became difficult to understand. Perhaps a simple technique of learning to understand the rules is required here.

4. How do we solve the problems

We first reviewed four important theoretical studies as to understand the problems of fire regulations and their applications in the design process. They are as follows;

4.1 BUILDING FIRE REGULATIONS

Building Fire Regulations have been analysed particularly in relation to the design process. By nature Building Fire Regulations are difficult for architects to learn and understand because of their complexity and ambiguity. Therefore, applying them in the design process is difficult for architects. We found that many architects have expressed the view that the fire regulations are very complicated and difficult to apply. Despite these problems and constraints, architects must comply with the regulations in their design. The key point here is how could architects easily use and apply fire regulations in the design process? Therefore, first, the architects must understand and need to learn about fire regulations.

4.2 ARCHITECTURAL DESIGN PROCESS

The nature of the architectural design process is unique especially during the early stages. We try to relate the design process and the applications of fire regulations in design. At the early stages, design is still ill-defined and architects are usually uncertain about the final outcome. Architects are still at the stage of trying to perceive and understand the problems as much as solving them. It is also the stage where architects want to become aware of any opportunities and constraints in the design.

However, because of the nature of fire regulations, their application in the design process is found to create many conflicts. Considering fire regulations in the early stage of the design process has many benefits. Most importantly, architects might understand more about the problems and constraints imposed by the rules in the design. That is why the design process has been said to be 'knowledge rich' rather than 'knowledge lean' Lawson (1993). However this activity requires a considerable amount of knowledge and therefore it is similarly applied to designing to comply with fire regulations, and requires knowledge about the regulations themselves. So far fire regulations have not been part of the design aspects that need to be considered in the design process because architects lack experience and knowledge of fire regulations. Furthermore fire regulations are not the prime generator in the design process. Could we design a system so that architects can consider fire regulations during the design process despite their level of knowledge? Could we **design a system** by the use of which architects can gain knowledge about fire regulations. Although fire regulations are not the prime generator of design, complying with them is essential. Could the system encourage architects to consider fire regulations in the design process by making sure that the system is easy to use and can help to improve design developments?

4.3 COMPUTER AIDED DESIGN

The computer is a basic technological tool essential to the architectural profession. We have reviewed how *the computer* has been used in the architectural profession (Rashid, 1997). The computer-aided design (CAD) system has been widely used especially in the production of drawings. Now attempts to use CAD to support the design process are being widely developed. In this project we want to use and recognise how the computer can help in attempts to solve fire regulations for architects to use in the design process. Based on an *ad hoc approach* and taking the role of *an advisor* could we have a computer system that could be pro-active in assisting and teaching the architects?

4.4 INTERVIEWS WITH PRACTICING ARCHITECTS AND FIRE AUTHORITIES

Two important points emerged from the *interviews*. **First**, at least the basic fire regulations should be considered from an early stage of design. Architects feel that earlier consideration of these requirements will prevent serious problems and prevent them from having to make major amendments in the later stages of design. In practice, the complication is greater than we thought. Architects have to consider important aspects of design other than fire regulations. To design and to conform to the regulations is a tedious and complicated process that requires experience and knowledge. Even experienced architects are still uncertain whether what they have designed conforms to the rules. This is because there is no method or yardstick to measure and know immediately whether the rules have been complied with during the design process, apart from comments made by the fire officers. **Second**, architects prefer someone else to *advise* him or her or undertake this work for them. So could we design a system to take the role of the advisor, which could give similar advice?

Based on the above factors, we attempt to propose a system that will have four characteristics as listed below;

1. It can reduce the difficulty of understanding and applying the building fire regulations.
2. The architects can easily apply the fire regulations and integrate them in the design process. It can also be applied at any stage of the design process.
3. The system is going to be a designer's tool. In the case of this thesis, it is a tool specifically for an early stage of the design process: it can quickly evaluate and assess the design according to the fire regulations requirements.
4. The role of the system will be to act as an assistant to architects in designing to comply with fire regulations.

5. The System

The proposed framework for the design of the system is based on several issues and important criteria. They are as follows;

1. Must have design data
2. Must be able to check and evaluate the rules
3. Must know the problems and why the problems occurred.
4. Must be able to give advice for remedying the problems.
5. Must be able to gain knowledge and enhance experiences.

Perhaps the discussion on these five criteria could be summarised by the diagram in Figure 1, which shows the mapping of all the components, and their relationship in organising the framework of the system.

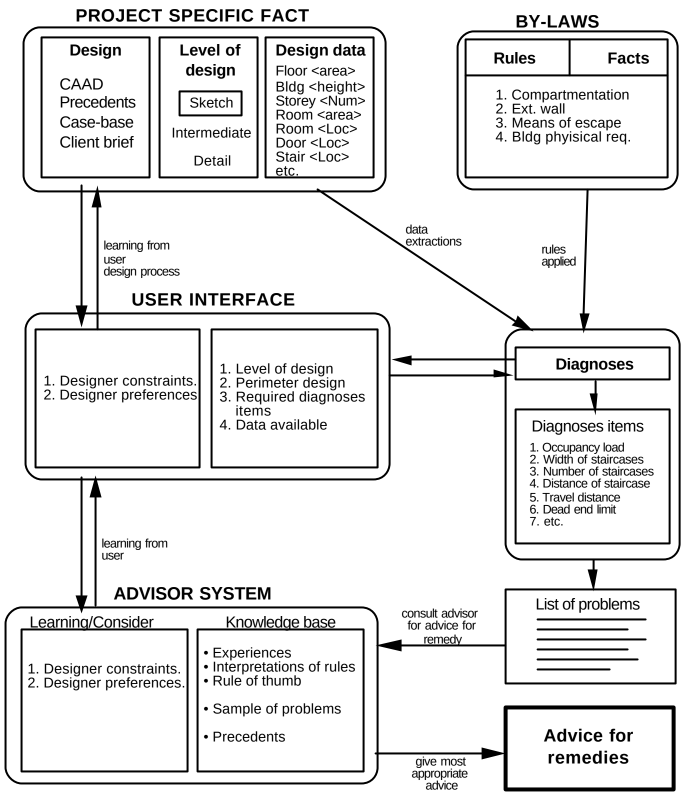


Figure 1 : The proposed framework of the prototype intelligent assistant system.

6. The example use of the system

The prototype has been developed using SuperCard v2.5, an object oriented program in the Apple Macintosh platform. The demonstration is intended to show three important criteria of the prototype that have been established in the above statements. The demonstration is intended to show that;

1. Architects can integrate fire regulations in the design process. The need for architects to integrated fire at the early stage of the design process has already been established in study done by Rashid (1997).
2. Architects do not require to understand the fire regulations fully, instead they will be given the opportunities to be able to understand better how the fire regulations can affect the design. Designing this system also aims to improve the architects' knowledge of fire regulations. We envisage that it will be an advantage if architects can not only use the system to assist them in conforming with fire regulations but can also learn how the fire regulations can affect their design. Architects can learn about the design variables and observe how the manipulation of the variables can affect the compliance of the design. Architects can learn about the problems and what causes the problems. In future they would be more aware of previous mistakes and try to avoid making the same mistakes again. By understanding all this, architects can learn indirectly and gain more knowledge about design and building regulations when they use the system. Therefore the system should allow this kind of learning process to take place and increase the 'knowledge rich' process. Perhaps we also envisage that this system could be used as a tool for architects to gain knowledge as Cross (1982) has stated that architects gain knowledge through a 'Designerly way of knowing'. The more the architects use the system the more they can understand and learn about the fire regulations and their implications for the design.
3. Architects will be given only appropriate advice, especially on the alternative solutions for any design problems. Giving appropriate advice will eliminate unnecessary amendments by the architects.

The system was designed as a tool for architects to assist them to comply with fire regulations. Diagram in Figure 2 explain the frameworks of advice giving. Its function is to enable architects to consider simultaneously the design and the building fire regulations during the early stages of the design process. The architects can use the system to consider fire regulations in the design process. They are as follows;

1. To get some general information (a 'tell me' function) on fire regulations that need to be given special attention when designing later.

2. To enquire about or to model the specific requirements of fire regulations with or without having a design. Most enquiries will use the function of the data survey module.
3. To check and evaluate the compliance of the design scheme according to the rules. However, this task will require at least a basic design scheme.

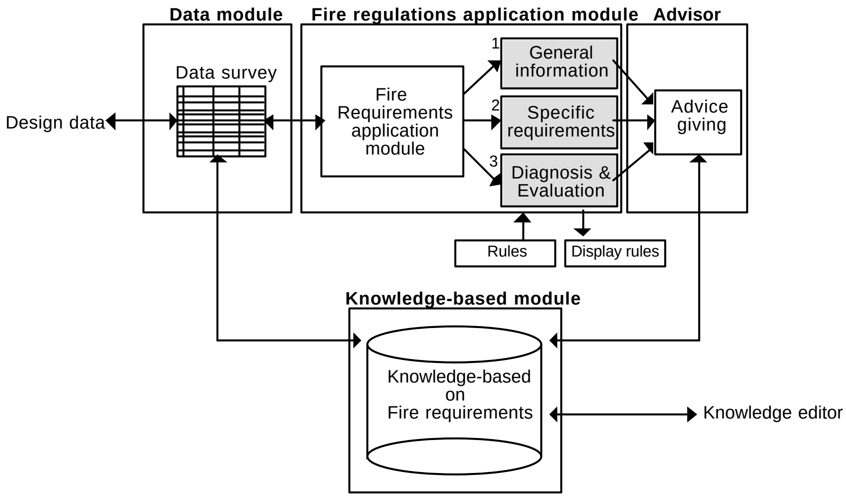


Figure 2 : The framework for the three categories of advice giving

As an example on how the system check and evaluate the design, let us refer to one of the scenario below. Architects can check and evaluate the compliance of the design with regulations from time to time until the design is finally completed. Throughout the design process, architects need to control the design so that it always complies with regulations. The controls are required in two vital aspects;

1. Specific design requirements the requirements of *the exit width, the number of staircases, the compartmentation, the width of the fire engine access road, unprotected opening* and *the active system requirements*. These will determine, the required dimensions such as width, length, height, thickness; the required sizes such as capacity, area; the required quantities such as numbers in which architects always need to be aware of. The data survey module will mainly handle these tasks. An example of this module for determining the number of staircases is shown in Figure 3.

2. The means of escape requirements, consists of another seven design variables. These variables are specifically concerned with distances and

measurements. Refer to Figure 4.

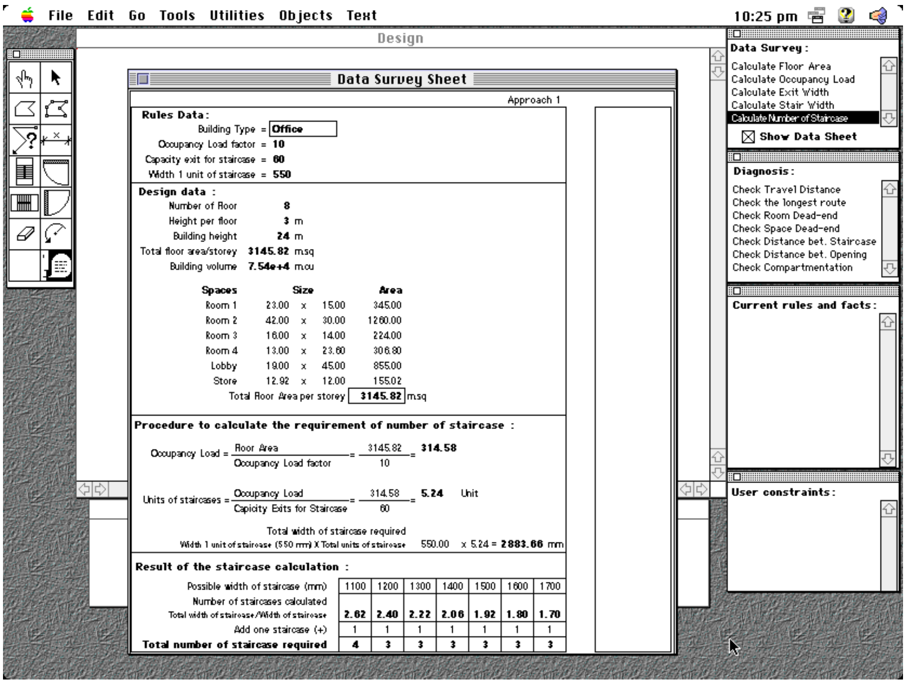


Figure 3 : Calculation for number of staircases using the data survey module

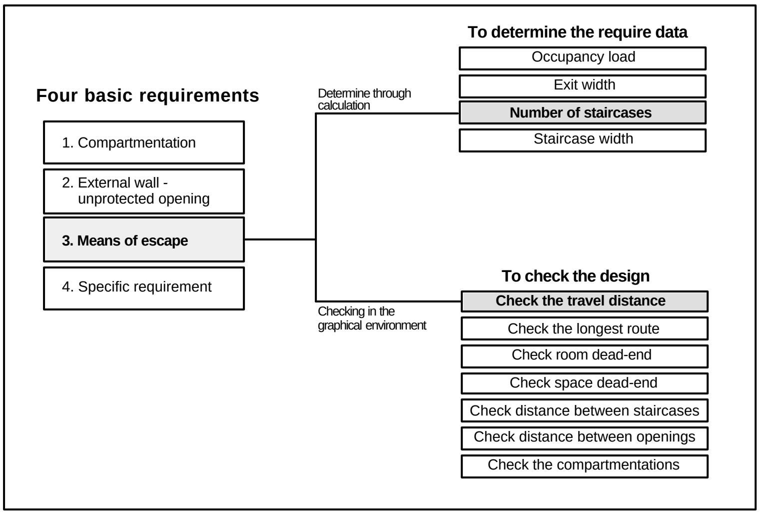


Figure 4 : The two chosen design requirements for the demonstration

Some basic geometrical representation of the design is also required in order to check and evaluate the design. The system can be used to check and evaluate the design in two methods,

1. Starting with the design sketch (the sketch can be made using the draw function in the system), as for example when the architects need to study the possible layout options for staircases position (Figure 5). The system evaluates the distance between the two staircases and advice the architect until the position that complies with the rule is determined.

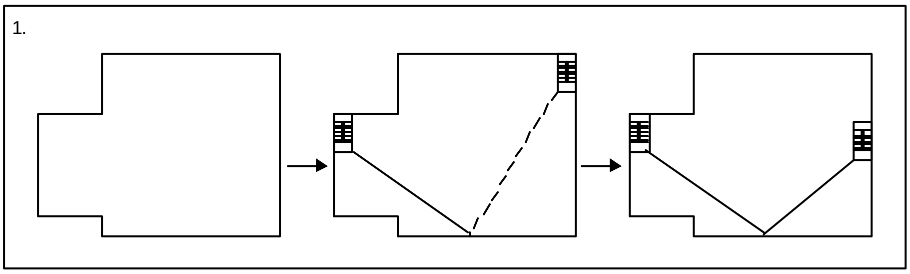


Figure 5 : The checking and evaluating are done from early sketch designs

2. The second methods is that some basic design layout has already been done using another CAAD system. Sometimes architects may use their previous design schemes for instance to re-evaluate the design and to find the changes in the requirements when new fire regulations have been implemented. We assume that there will be an export facility to extract the existing design data into the system. Here the architects can straight away check the design and find out if there are any problems with the first scheme proposed (Figure 6). The only difference compared with the first one is that there is a possibility of many design problems since the design is only being checked when it has already half-completed. Although there will be many problems, architects can still get comments and advice on the design from the system.

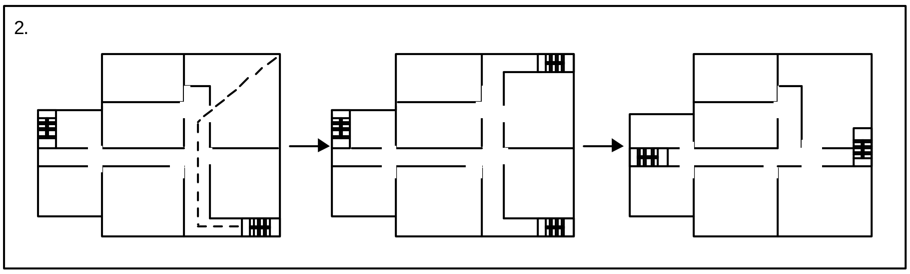


Figure 6 : Checking the design with a complete layout.

As for the prototype, the design is based on windows environment. It has three windows and several palettes. The main window is the *Design* window and the other two are the *Comment* window and the *Advice* window. The palettes are comprised of *Tools*, *Data Survey*, *Diagnosis*, *Current rules and facts* and *User constraints* palettes. The basic screen layout is shown in Figure 7. It is not within the scope of this paper to describe and discuss the interface design of the system. However, we could envisage that the interface design of the prototype should enable the architects to access the system at any time during the design process. It should also allow the architects to be able to manipulate and edit the design immediately by using the system. Finally, we want the user to have the final control of the system and be able to decide on what to check and to evaluate the design. Diagram in Figure 8 and 9 demonstrate the application of the system to check and evaluate the design according to the rules.

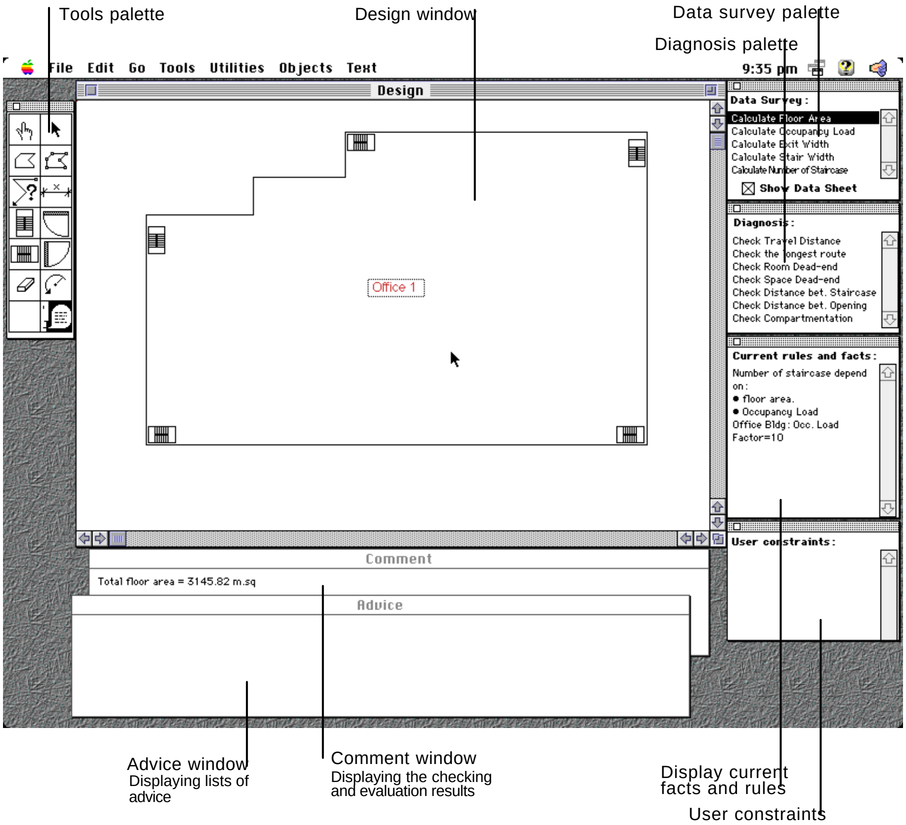


Figure 7 : A basic screen layout of the system

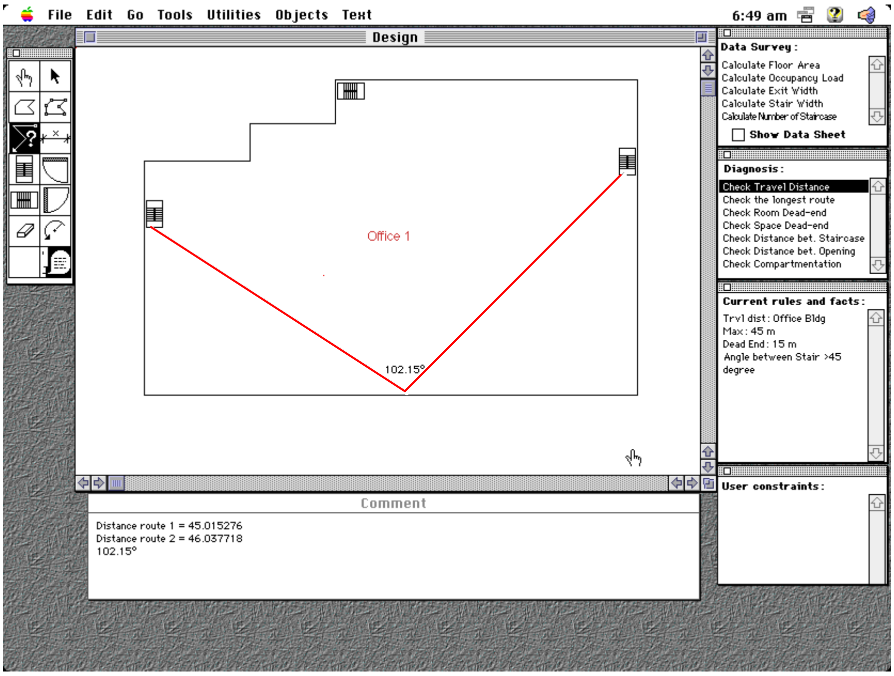


Figure 8: Measuring the travel distance requirement

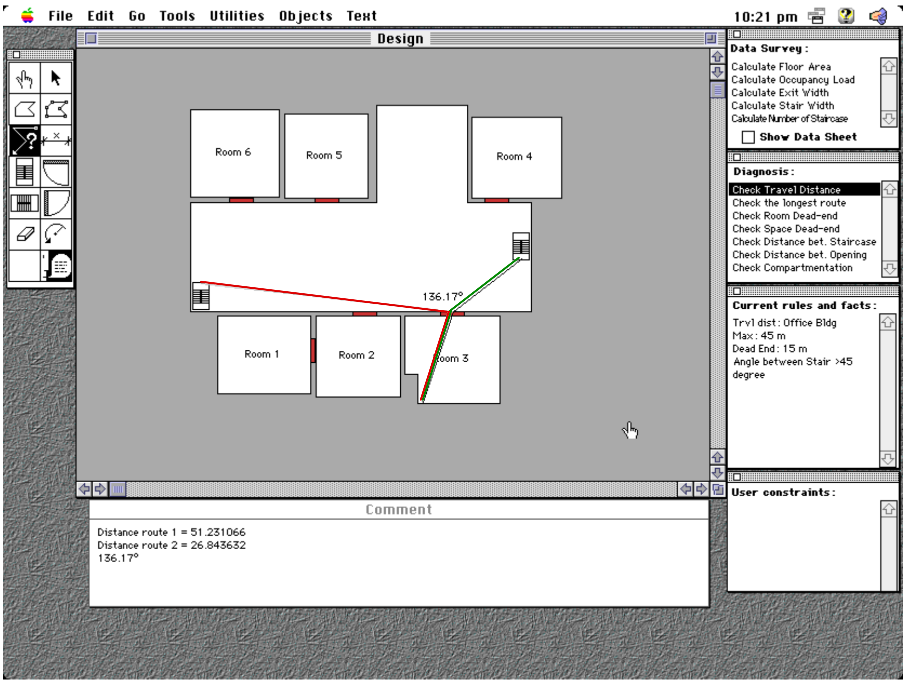


Figure 9 : Checking and evaluating of travel distance for compartmental design

7. The advice giving scenario

The scenario given here the way to escape from the corridor to the exit staircase. Escape within the second stage will include the distance from the first stage. Therefore, the total travel distance is the distance from within the room plus the distance from the door to the staircase. Refer to Figure 10. For example, in an office building the total travel distance limit is 45m.

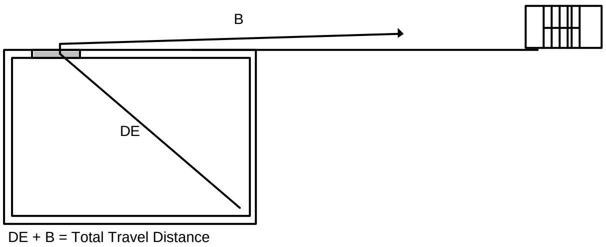
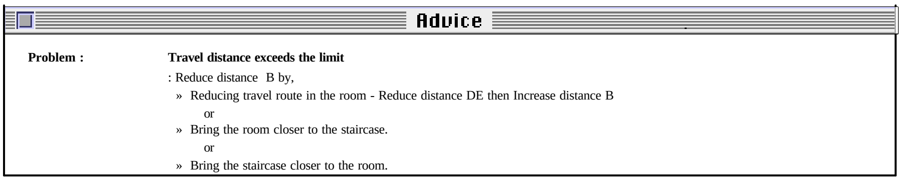


Figure 10 : The total travel distance exceeds the maximum limit.

If the maximum travel distance for office buildings is 45m and the dead-end is 15m, then distance B is = 45 - 15 = 30m only. However, many cases show that distance B exceeds 30m although distance DE has been satisfied. Therefore in the evaluation, the system will still notify the user that the travel distance exceeds the limit.



As the first priority, the system will advise the architects to modify the room if it is possible. By reducing the travel route of the room, it will reduce the distance of DE. That means it can only be done by modifying the room's layout or by repositioning the location of the door (Figure 11). If the first suggestion does not work, the architects can try the second and the third suggestions. If the problem still cannot be solved by the alternative solutions given, it means that the locations of the staircases are too far from the room (Figure 12).

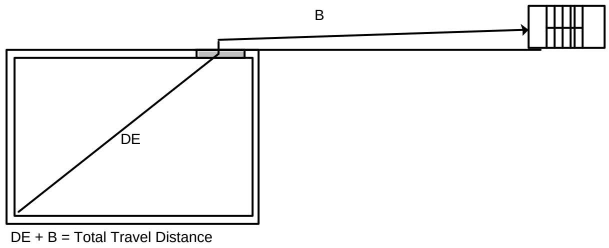


Figure 11 : Remedy by relocating the position of the door

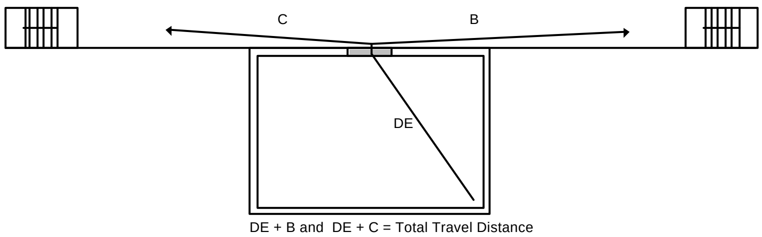


Figure 12 : Locations of staircases are too far from the room

In order to solve the above problem, the system will give extra advice that usually will involve a major amendment to the design, such as the advice given below.

Advice

Problem : **Travel distance exceeds the limit**

.... continue from above.
» Modify the room layout
» Add another door
or
» Adjust the location of the staircase
or
» Adjust the location of the staircase and used dead-end provisions
or
» Add another staircase.

These are some examples of how the system performs the diagnosis and gives advice on design problems. The architects can modify the design during this consultation and simultaneously they can learn the principles and the overall fire regulations requirements that might affect the design. As for the advisor, perhaps more knowledge about solving fire regulations requirements can be acquired in order to improve its capability. The facts and the information should always be updated according to the development of fire safety requirements.

8. Conclusion

The work attempts to design a computer system that helps students or architects to understand fire regulations through their design process. The system enables to reduce the difficulties in understanding the meaning of building fire regulations and its requirements. One of the big steps improved is that the students and architects can learn about the rules and its requirements directly through an interactive environment system. The system also be able to give advice on related fire regulations problems and most importantly is to advice on how to remedy the design problems. This work is a beginning and will be further developed.

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