

BUILDING A PERGOLA IN CAD SYSTEMS

Abstract: In this paper the authors present a study and the conclusions they reached, regarding the possibility to automatically representing a pergola, when a CAD system is used. Also, a computer program, made by the authors is presented. This software was named Pergola and it offer the opportunity to sketch a pergola which cover a rectangular or circular area, when using the AutoCAD Architecture or AutoCAD computer program.

Key words: Pergola, AutoCAD, AutoCAD Architecture, AutoLISP, Parametric Drawing, 3D Modelling.

1. INTRODUCTION

The pergola is a structure which can often be found between the decorative and non-decorative elements from a garden. This can be built in one of the following purposes: to offer a space for relaxing, protected from sun rays or to give to people a shaded walkway or passageway. The surface which is covered by the roof of the pergola, is bounded by vertical pillars that usually support beams on which, an open lattice is supported. Most times on this structure is allowed to grow plants, such as ivy, vines, roses etc., to having greenery all year round and more shade. If the roof is closed, another structure, called pavilion, will be obtained. From the architect's point of view, both pergola and pavilion, are an outdoor extension of the living room and from this reason these must be treated very seriously.

In the most cases, pergola covers a rectangular or circular surface. There are situations, in which it can also cover other surfaces like triangles, arcs and so on.

The way in that the pergola looks is defined, at least, by the help of three factors. The first factor is related to the pillars which sustain the roof. These may have different dimensions, they may be decorated in different ways and may be fixed in the ground, using different solutions depending on the place in which the pergola will be placed. The second factor is related to the open lattice sustained by the pillars. This is composed from roof supports, rafters and roof slats. The rafters and roof slats, put together, forms what is named, the open lattice which has the goals to stop a part of the sun rays, and to allow to the air to move on the vertical, beyond the open roof, thus, offering a refreshing space even in the sunny and hot days. Well, this open roof may have a plane or curve surface. Its components may have different colors and may be designed with the ends having different ornamental shapes. Also, their mode of connection can be different from one open roof to another. Finally, the third factor is related to the material it is constructed pergola. The elegant solution is to use the timber as a building material. It has the disadvantage that requires effort in terms of maintenance over time of the pergola. This shortcoming is removed when the vinyl flooring is used, as a building material.

So it can be said that a pergola is a structure which may have various forms, miscellaneous decorative elements, with many jointing solutions of the elements

which forming part from its composition, having different colors, made from timber or vinyl flooring.

2. IDENTIFICATION OF A PROGRAMMABLE MODEL

In order to build a software designed to represent a pergola in a CAD system, it is necessary, first of all, to set a generic model which can be managed entirely in a CAD system and which, in the same time, can be modelled with a programming language accepted by the used system. The model must have not ambiguities and easy, as much it is possible, to be handled by the chosen programming language.

At a first glance, from the short description of pergola from above, seems to result that is not very difficult to find a proper model. But, analysing more carefully, it becomes obvious that this is not an easy job because there is an impossible number to estimate of ways in that a pergola may look [1], [2], [3]. The number S of ways in that, a pergola may look, can be estimated with the help of the equation (1).

$$S = A \cdot F \cdot P_1 \cdot P_2 \cdot R \cdot K_1 \cdot K_2 \cdot E_1 \cdot E_2 \cdot D_1 \cdot D_2 \quad (1)$$

Where:

- A reflects the number of the forms of the surfaces covered by the pergola;
- F means the number of ways used to fix the pergola on the ground;
- P_1 is the number of the dimensions of the sections which may be adopted for pillars;
- P_2 reflects the number of ways in that may look the pillars, from the point of view of the ornaments;
- R the roof aspect (flat or arched);
- K_1 the modes of fastening of the rafters on the pillars;
- K_2 the modes of fastening of the rafters;
- E_1 the numbers of the ornamental shapes of the rafters;
- E_2 the numbers of the ornamental shapes of the roof slats;
- D_1 the numbers of the shapes of the diagonal braces;
- D_2 the numbers of the ornamental forms of the diagonal braces.

In the equation (1) there are terms that are easy to estimate, like A, F, P_1 or R. But, other are very difficult to be evaluated or maybe even impossible, like D_2 which

depends, among others, by designers' creativity and by the fashion.

So, analysing the equation (1) the authors have concluded that may exist two types of model. One of them was named the *complete model* and this takes into account all the elements presented in the equation (1) and must manage them in the same session of generation of the pergola. The other model, named *parametric model*, implies transposing of each projected model of pergola, into a computer model, whose dimensions can be varied in a precise range of values, previous established by engineers and architects.

2.1 The complete model

This type of model must offer to the users the possibility that, starting from a certain requirement, made by a customer and using all the details about pergola explained above, to obtain a pergola, in a CAD system. But, as already explained above, there are parts of the pergola, like diagonal braces, that are very difficult to be included in the model, because of the issues caused by the ornamental forms. There are cases in that they do not have any ornamental element or, on the contrary, there are cases in that they have very complex ornamental elements which can be modified, in time, according to the fashion or from the future customers' desire [1], [3].

The authors have decided that the best solution for this model is to split in two categories the component parts of a pergola.

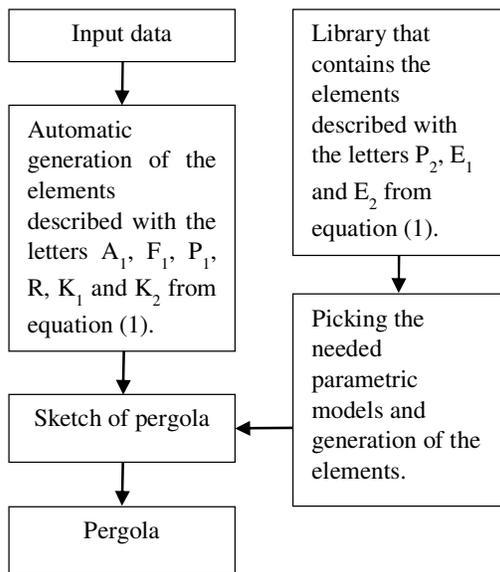


Fig. 1 The workflow for the complete model.

The first category is referring to the parts that can be managed from the point of view of the aspect and dimensions. For example, the dimensions of the sections of the pillars. Generally, these sections are square, with the following dimensions 10x10 cm, 12x12 cm and 14x14cm. These types of parts can be included in a programmable structure. That means it is possible to write a computer program in that the user inserts the dimensions of the part and the CAD system it generates

automatically.

The second category is referring to the parts which can take too many shapes and who can be modified from time to time according to the fashion. In this case is very difficult or even impossible to write a computer program. The solution is to build a parametric model for each element which can evolve in time, in an unpredictable manner and to make, with all of these parametric models, a library. In this way the new parametric models that arising from the fashion of the time, can be added and, when will be the case, it will be easy to modify any model.

The workflow will be: in a first step, a sketch of a pergola will be obtained using a computer program which processes data described by the help of terms A_1 , F_1 , P_1 , R , K_1 and K_2 . In the second step will choose, from a library, needed parts of the pergola which will be joined to the already sketched pergola, see fig. 1.

2.2 The parametric model

In this case, for each type of pergola, a parametric model must be created. This model must include all the data described by all the terms from equation (1). It is very important to be established, with maximum accuracy, the range in that, each date can vary or the particular values which can be selected by the user for a specified date.

Another requirement, which is very difficult to achieve, is to correlate the values of some data with values other data. For example, the section of the pillars and the complexity of the open roof, or the section of the beams which support the rafters and the distance between the pillars and so on.

In this case the workflow is presented in fig. 2.

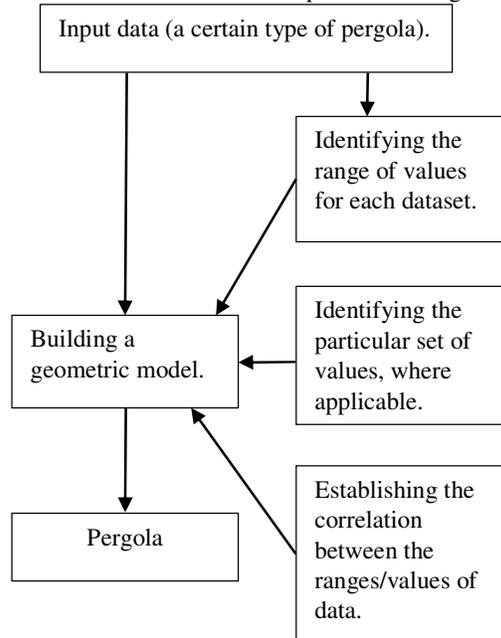


Fig. 2 The workflow for the parametric model.

3. THE COMPUTER PROGRAM PERGOLA

The authors started a project for the construction of a complete model. The project has two parts. A part aims to build a computer program that offer the possibility to sketch a pergola, taking in to account, the data described by the terms A_1 , F_1 , P_1 , R , K_1 and K_2 from equation (1). The goal of the other party of the project is to obtain a large library with parametric models for different elements described by the terms P_2 , E_1 and E_2 from equation (1).

The computer program is named Pergola. It offer the possibility to sketch a pergola which cover a rectangular or circular surface. The program starts by asking the user to select the type of surface which will be covered by the pergola, see Fig. 3.

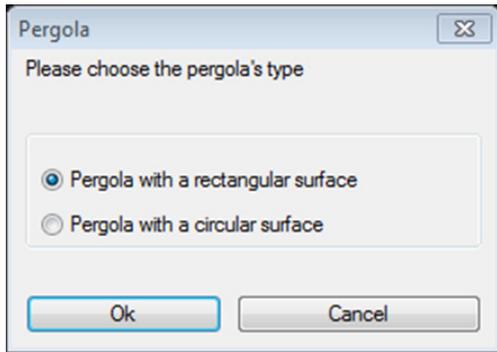


Fig. 3 The choosing of the pergola's surface.

If the user chooses to sketch a pergola which cover a rectangular surface, the computer program will ask him to specify the length and the width of the surface, see Fig. 4.

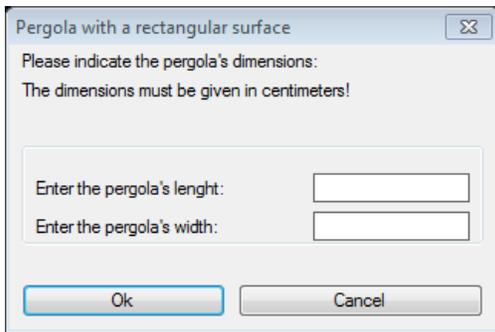


Fig. 4 The insert of the dimensions of the surface.

The next step is it to introduce the height of the pergola. As can be seen in Fig. 5, it is possible to insert two values. If the values are equal, the roof will be in a horizontal position. In case that, two different values will be given, the resulting roof will be a sloped one.

The computer program Pergola offer the possibility to sketch a pergola with sloped roof because are cases in that a pergola has a such kind of roof, encountered most often, when the pergola is built starting from a wall of the house.

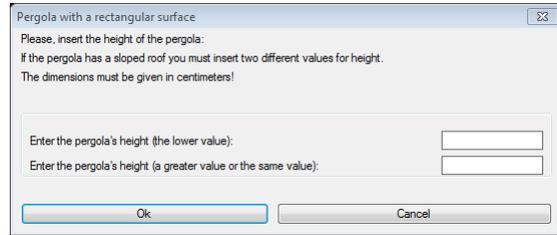


Fig 5 The dialog box for height and slope of the roof.

Once the height was established, it is necessary to be inserted the distance between posts and the section of the posts, see Fig. 6. The computer program Pergola assumes that the sections of the posts are always in shape of square.

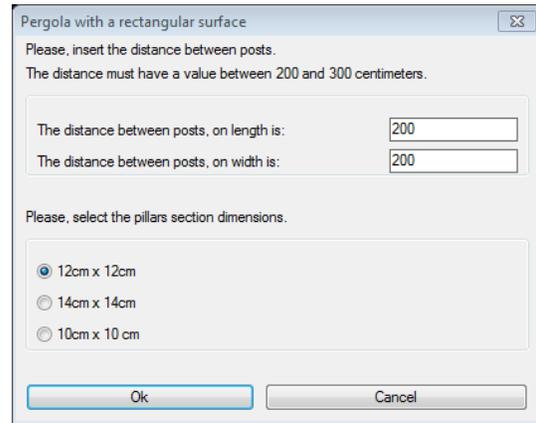


Fig. 6 The distance between posts and their sections.

After all these data have been inserted, a sketch of a pergola with a horizontal or sloped roof will be represented, see Fig. 7 and Fig. 8.

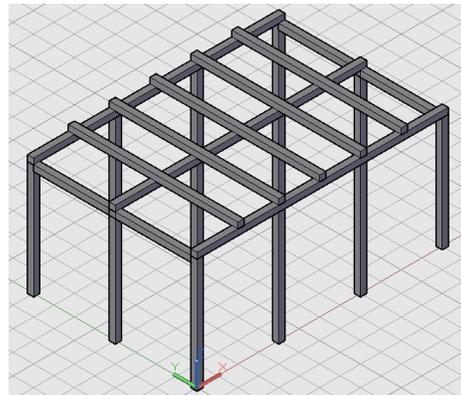


Fig. 7 A pergola with a horizontal roof.

The computer program Pergola, analyses all the input data. If their values are not inscribed in a certain range it gives an error message in which the user is informed about the nature of error and, in the same time, indicates the limits values of the interval or the particular values which can be selected, see Fig. 9.

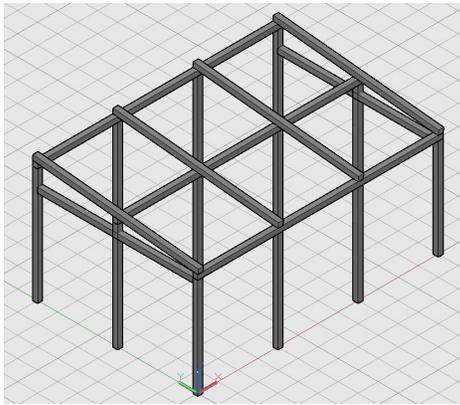


Fig. 8 A pergola with a sloped roof.

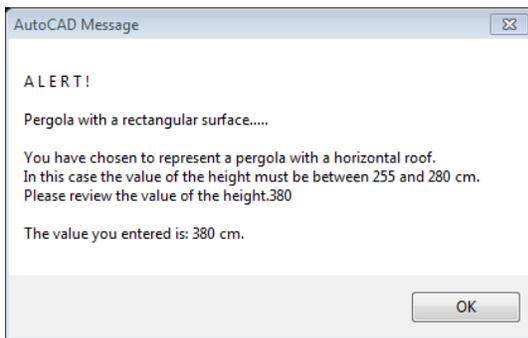


Fig. 9 An alert message.

If the user has need a pergola which covers a circular surface, he must indicate the diameter of the pergola, the number of posts and the height of the pergola. After that, the computer program will sketch a pergola, see Fig. 10.

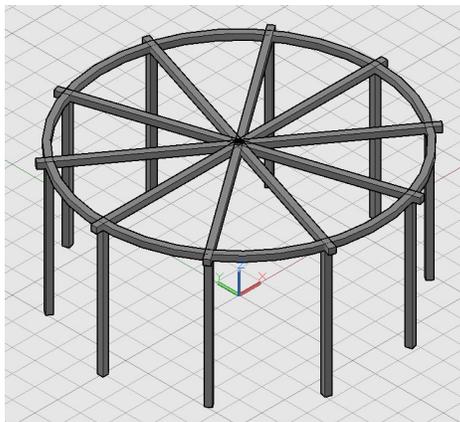


Fig. 10 A pergola with a circular roof.

The represented model is obtained with the mesh command therefore, the different parts of the model can be easily modified if it is necessary [4]. Another advantage of using the mesh command is that the obtained graphical structure can be exported to other graphical programs, such as SketchUp.

The computer program has an open structure, thus, new modules can be easily added. For example, a module for a pergola which cover a triangular surface is needed.

In order to obtain a complete model for a pergola, in future, is necessary to build a parametric model for each element that cannot be obtained with the computer program Pergola help. Finally, with all these parametric models, a library must be done.

4. CONCLUSION

The authors have established, that the process of building of a pergola in CAD system can be approached in two ways: using the *complete model* or using the *parametric model*.

The complete model means to build a computer program that gives the possibility to represent some elements, which belong to the pergola and, in order to successfully complete the structure, the other elements must be parameterized and kept in a library.

The *parametric model* means to build, for each type of pergola, a parametric model which must include all the elements belonging of the pergola.

Also, the authors have made a computer program, named Pergola, which offer the possibility to sketching a pergola, as part of a *complete model*. This software may represent a pergola which cover rectangular or circular surface.

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