Aided decision and authentication of lamellated wood frameworks.

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Abstract

The lameleted gluthed timber frame design needs many actors : architect, carpenter, different reseach departements... each of them has their work worry. Because of the increasing difficulty of the buildings, it becomes necessary to develop somes logiciel tools to choose the assembly beetveen the beams, to respect the mechanical resistance safety, to keep in conformity with the European standard.

1 Introduction

The expansion of manufacturing and implementation techniques of lamellated timber encourages its use in construction of buildings of all sizes and all shapes apart from the fact that this material possesses very interesting features and pleasant design ; beside the other materials, it present a good resistance to fire, a slight density and a great flexibility in work. Moreover, it is natural and renewable.
Lamellated timber is the result of boards planed down in the sides and then sticked together thought piling-up.
It has mechanical qualities higher than of solid timber from which it is manufactured; the process of manufacturing permits to eliminate timber's blemishes such as knots, splits, cracks, etc.
Lamellated timbers from classes I and II allow bending stresses higher by order 10% than that allowed by solid timber .
It also allows transverse sharing stresses superior by 33% and an elasticity modulus appreciably better with the grain (SNCCBLC, 1994)

2 Framework

A framework is a set of beams joined together with the help of assemblies in order to give this set its final shape and to allow it to carry the weight it has to.

2.1 European regulation of timber structures

The whole European standards regarding the calculation of timber structure form a document called Eurocodes 5. It deals with all timber qualities such as solid, lamellated wood timber, panels, as well as with all the rules of authorised assemblies and the way they must be worked. In a first time, the data processing model proposed in this paper only treats of the lamellated timber part and the metal structures dedicated to that kind of framework (Eurocode5, 1995).

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2.2 Design and creation of a framework

The design of a framework requires many interventions of the architect, carpenter and also that of the different research departments which leads to an important number of modifications of the frame(Le Govic C., 1997). Its design is composed of the following stages:

1) the architect defines the frame's global shape precising the useful volumes of the building, the voluminal constraints of the structure and its design restraint.
2) the project is submitted to a carpenter so that he can give his views on the structure feasibility.
3) a research department creates the mechanical study of the frame and defines:
   3.1) the frame's skeleton by all the beams that compose it.
   3.2) the dimensions of each beam according to the loads transfer
   3.3) the different elements of assembly of the beams according to the final geometry of frame
   3.4) a new calculation of dimensions of the beams if the chosen assembly imposes to overcalculate the dimensions of the beams on which it settles itself.
   3.5) the authentication of assembly according to European standards (Eurocodes 5)
4) the carpenter can now start on the manufacturing step of the beams in factory.
5) the carpenter ensures the delivery and makes the assembly on the site where the frame takes place.

2.3 the problems related to design

The increasing complexity of the buildings leads the designer to solve problems that are more and more difficult.

According to a survey led in Franche-Comté, a forested region in France, concerning the constructors of lamellated timber frames, it appears that they lack data processing tools to help them in their task.

During steps of design 3.3, 3.4, 3.5, the designer doesn't have any data processing tools at his disposal and must call on his own experience to solve the problem. He has to manage a great number of parameters and an infinite number of possibilities concerning the creation of assembly. Moreover, after he has retained a solution, he must check this one complies with the Eurocode 5

They explained us their difficulties to resolve the following points :

- choosing the optimal assembly among the vast number of standard assemblies
- conceiving a new assembly answering the problem
- concatenating different basic assemblies to obtain a complex assembly
- taking into account the problems of assembly, the resistance to fire and the design of the work.

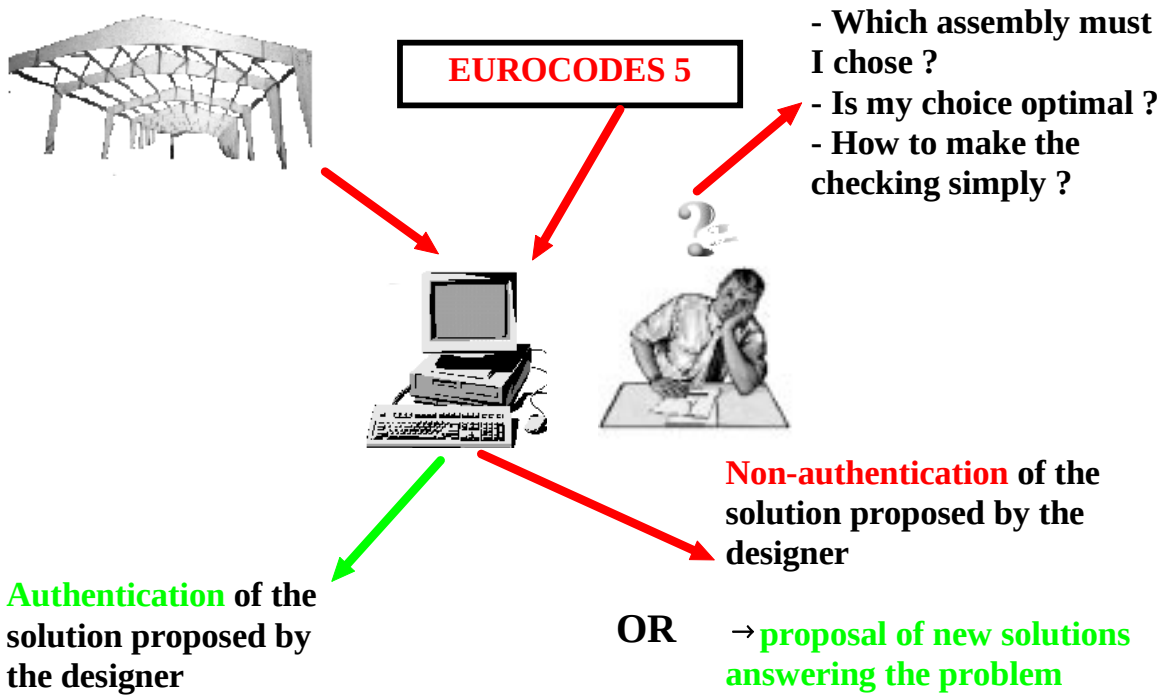

Fig. 1 : presentation of the problem.

3 Problematic related to assemblies

3.1 Composition of an assembly

It consist in metal elements that have several functions (Götz k.-l..et al, 1987 ; Natterer J.et al 1994, Lavigne, 1998) :

- fixing several beams together ;
- defining one or several mechanical connections between the beams (embedding, pivot, ball joint) ;
- giving the structure its final shape

They must answer several parameters such as :

- taking into account the timber's mechanical properties ;
- the easiness of the assembly ;
- the resistance to fire ;
- the design.

An assembly is composed of metal plates (hinges) that are settled on the beams through the medium of the fastening elements (SNCCBLC, 1994).

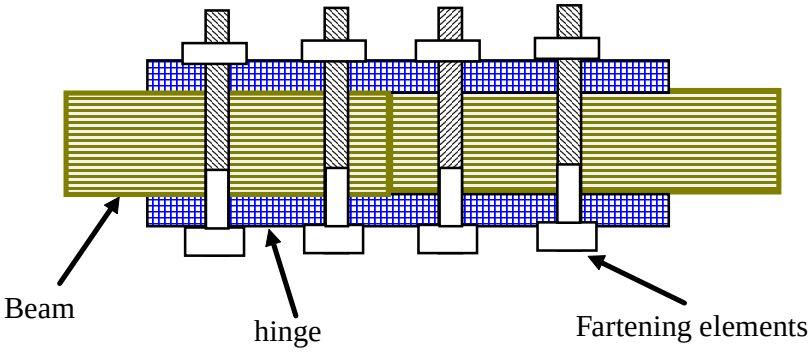

Fig. 2 : formation of an assembly.

The setting of the fastening elements of the assemblies on the beams is made according to rules adapted to each type of fastening systems (Hazard .C et al , 1996).
These rules are provided by Eurocodes 5 and Cb71 (Eurocode5, 1995 ; CB71,1984).

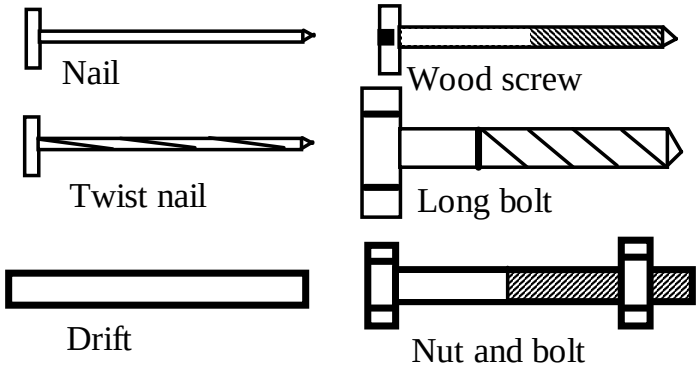

Fig. 3 : Various fastening elements.

The assemblies must be decomposed into two classes :

- the basic ones,
- the complex ones.

Basic assemblies only ensure a one and only mechanical connection between several beams as well as the associate geometry.

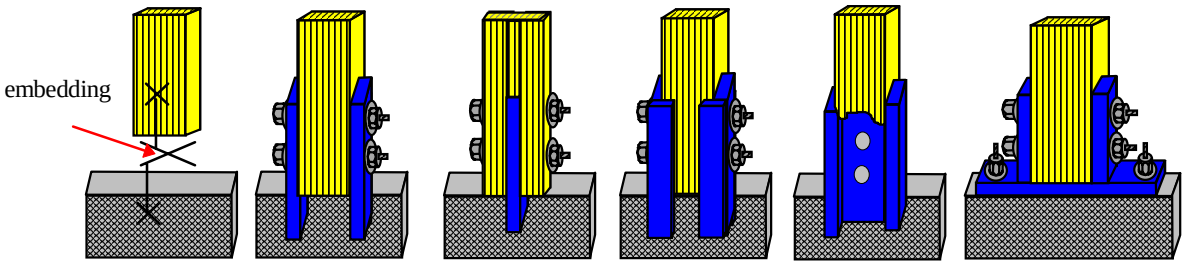

Fig. 4 : example of solutions to create a basic assembly.

The preceding examples show the great number of solutions that exist to fix a post on the ground. It also shows that each assembly doesn't have the same weight capacity. Complex assemblies are the combination of several basic assemblies.

The following illustration shows an example of creation of complex assemblies, an embedded connection, a pivot connection and possibilities of taking the design into account (visibly, semi-hidden, totally hidden).

In a great number of cases, the carpenter is brought to create complex assemblies. To do so, many solutions occur to him.

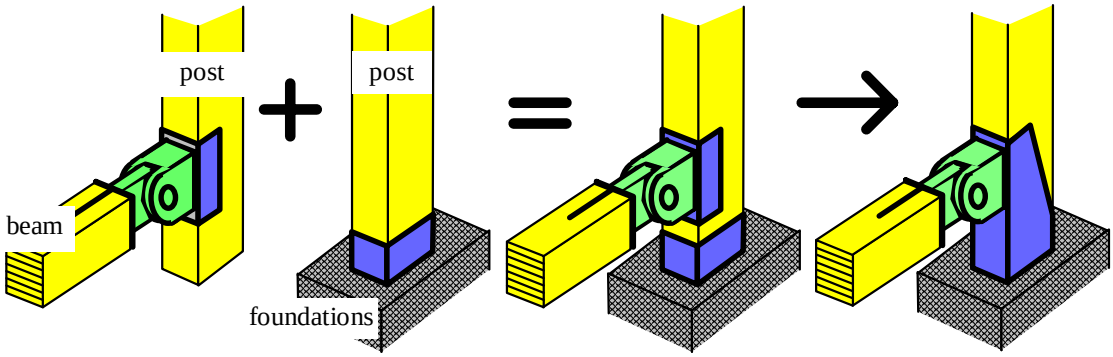

Fig. 5 : example of concatenation of two basic assemblies

3.3 Modelling of an assembly

- the kernel describes the mechanical connection and the geometry related to a basic assembly.
- the node is the combination of all the kernels and it imparts the final geometry of assembly.
- the interface is the part fixing the beam.

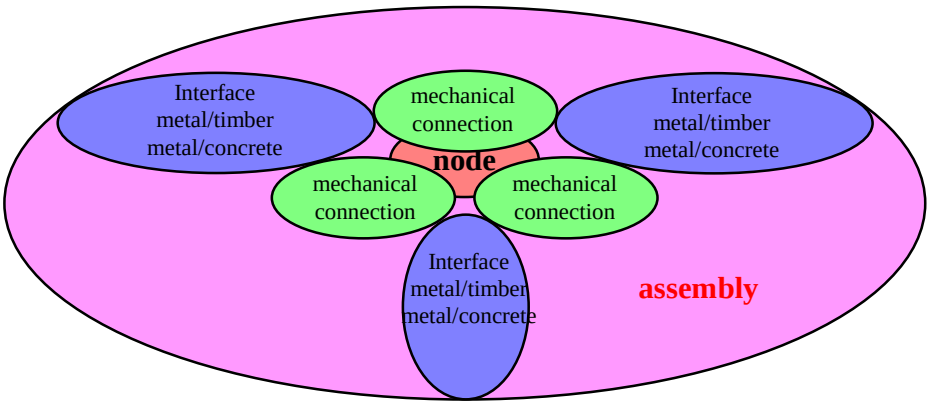

Fig. 6 : modelling of an assembly.

4 Solving element

4.1 The system

We chose to develop an aided decision system (KBS) for it is the type of system that is best adapted to the problem.

First of all, this system must answer its designer's needs and must be understood by him. In our case, we address ourselves to a large audience that goes from the carpenter, who acquired his training on the job to the architect qualified in frame. These people don't have the same data processing basis at all but they have the same needs.

To permit our system to be used by everyone, we chose to make the keyboarding of different parameters through graphics screens.

4.2) the interface man/machine

In a first time, the user must chose the type of basic structure (Natterer J.et al 1994), (Fig. 7) around which the building will be created.

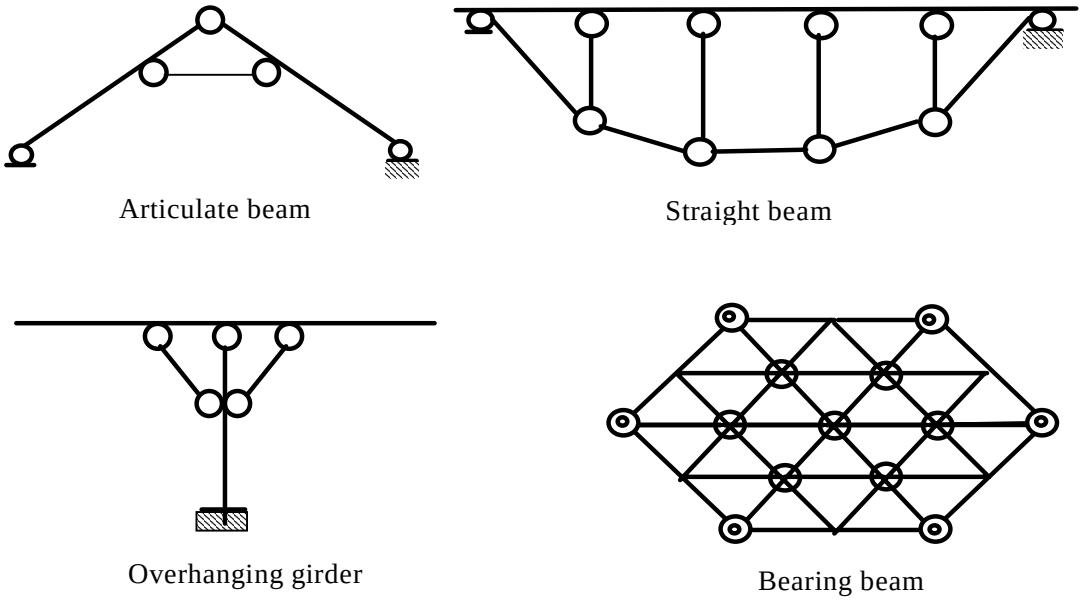

Fig. 7 : example of basic structures

Once the structure is chosen, the user can introduce the parameters regarding each beam as well as the choice of assembly though its schematic representation.

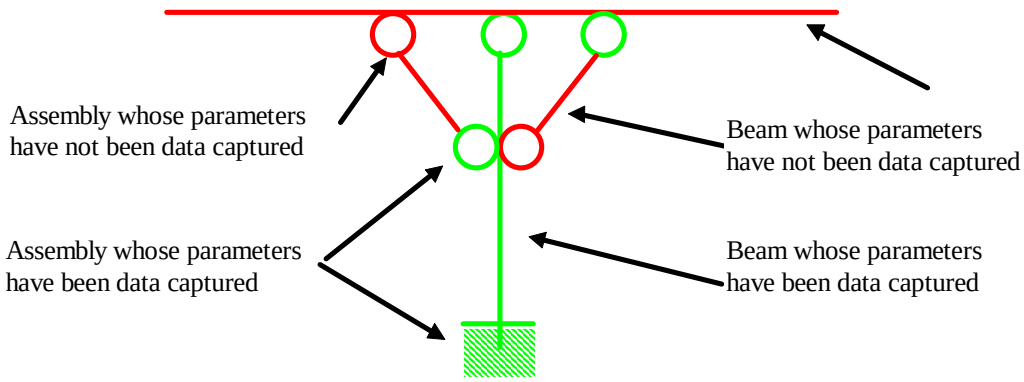

Fig. 8 : description of the data captured mode

4.3 Analysis of the system

To create our system, we called on SADT analysis in order to make a good difference between the operations it has to execute as well as the data he has to treat.

Our system is composed of a data base divided into three sub-groups that are Eurocodes5, assemblies, fastening elements. The database related to Eurocodes 5 is composed of a part that deals with the modifications brought by the country within which the frame will be settled (Fig. 9).

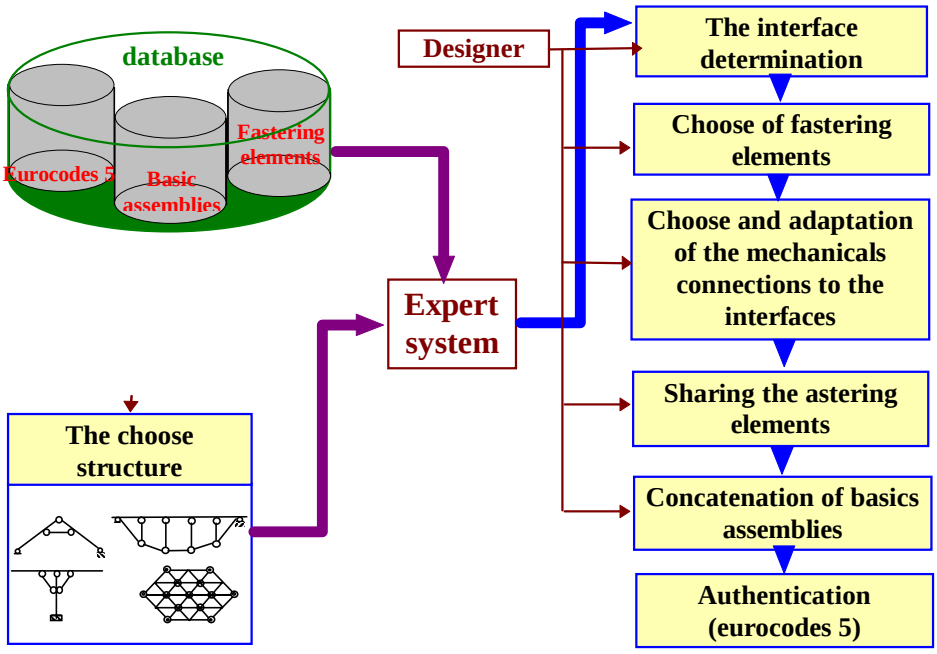

Fig.9 : synoptic of the system

The expert system is in charge of the capture of the informations related to assembly :
- number of beams to link up,
- mechanical connections,

- fastening elements to be used.

It possesses a module of fuzzy logic allowing to take into account the user's notion of design for this parameter is very hard to quantify and can absolutely not be made in a binary way.

After, if it's necessary, it creates a complex assembly which answers to the above defined criterions. It arranges the fastening elements so that the beams are not overcalculated and the assembly area remains accessible. It makes the authentication conformity with Eurocodes 5.

Once the authentication test is made, two solutions are possible :

- Assembly is authenticated and the solution is proposed to the user.
- there is no authentication and the system informs the user on the causes of the non-authentication. Then the user can modify a few parameters to allow a new search.

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